ANÆSTHESIA IN DENTAL SURGERY

THOMAS D. LUKE & J. STUART ROSS

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BY THE LATE

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WITH A CHAPTER UPON

LOCAL AND REGIONAL ANÆSTHESIA

BY

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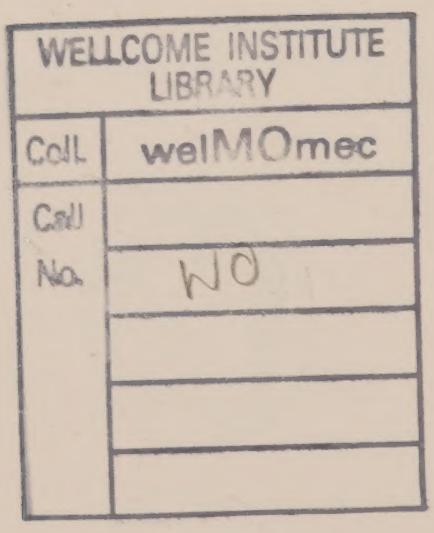

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PREFACE TO FIFTH EDITION

The lamented and premature death of Thomas Davy Luke has placed upon me the sole responsibility for preparing the present edition for the press. The fact that in less than twenty years the book has run through four editions shows how sound were the lines upon which my old friend originally conceived it. Even to-day much that he wrote upon dental anæsthesia is as true as ever, and I have left such passages untouched. But during the last few years progress has been unusually rapid, both in the science and practice of anæsthetics, and the greater part of the book has therefore been entirely rewritten. Particularly is this the case in the chapter devoted to Gas and Oxygen, in which it is hoped that full justice has been done to modern methods and apparatus.

The book remains as essentially intended for the dental student and practitioner, and for the medical practitioner who may wish to take up dental anæsthetics and realizes that some additional study is required to adapt his knowledge

of surgical anæsthetics to the requirements of dental work. To overweight a book written with that objective by long discussions upon physiological points would be a mistake. Those who wish to go fully into that aspect of the subject are referred to such a book as Blomfield's 'Anæsthetics in Practice and Theory,' or to the author's own 'Handbook of Anæsthetics' (E. and S. Livingstone). But at the present day it is hopeless to attempt the teaching of any branch of anæsthetics without some mention of the pharmacological action of the various drugs, and, even more important, of the physiological effects of alterations in the blood-gases; and it is hoped that the references to these subjects in the present edition will be found adequate for the requirements of the student.

In committing the chapter upon Local Anæsthesia to the hands of Major Finlayson, I was satisfied that real justice would be done to the subject. It is so closely linked up with operative dentistry that only if written by a practising dental surgeon can the chapter have behind it the force of real authority. My sincere thanks are due to Major Finlayson for the admirable way in which he has carried out his task.

I wish to express also my thanks to the following firms for the loan of the electros for many of the

illustrations: Claudius Ash and Company; Messrs. Allen and Hanburys; Messrs. G. Barth; Messrs. Coxeter and Son; The Foregger Company, Inc. Largely owing to their kind assistance, the present edition will be found to be more freely illustrated than the previous one.

Figs. 43, 44, and 45 are from photographs of the skull, and I wish to thank my friend Mr. Frank Richardson, Student of Medicine, for the trouble which he took to arrange the specimen in such a way as best to show up the various foramina concerned in Regional Anæsthesia, and also Mr. McKechnie for taking the very fine photographs from which the plates have been prepared.

A synopsis has been substituted for the index of former editions. I hope that the book is now written in logical sequence, and that the various cross-references given in the text of the book itself will be found more useful than a mere index.

J. S. ROSS.

52, Murrayfield Gardens,
Edinburgh.

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CHAPTER I

THE HISTORY OF ANÆSTHESIA

Pioneers of Anæsthetics.

Nitrous Oxide.

Joseph Priestley (England) - - -	1776
Humphry Davy ,, - - -	1800
Horace Wells,* Collyer, Colton, Riggs,* Evans* (U.S.A.), Bert (France) - - -	1844

Ethyl Chloride.

Heyfelder - - - - - -	1848
B. W. Richardson - - - -	1867
Carlson - - - - - -	1896
McCardie, Luke - - - - -	1900

Sulphuric Ether.

M. Faraday - - - - -	1818
W. T. G. Morton* (on himself and on Eben. H. Frost, at Boston, U.S.A.) - - -	1846

'Before whom, in all time, surgery was agony. Since whom Science has control of pain.'

J. C. Warren (on Gilbert Abbot, 20, painter, single), Long, Jackson, Hayward, Bigelow, Boot,* Robinson,* Liston, Buchanan, Longet, John Snow, Simpson, Bernard, Clover -	1846

Chloroform.

James Young Simpson - - - -	1847
Guthrie, Soubeiran, Liebig - -	1813
Dumas - - - - - -	1834

Associated with Waldie, Flourens, G. Keith, M. Duncan, Snow, Nunneley, James Arnott.

The extraction of teeth has from the earliest times been looked upon as a most painful and trying

* Dentists.

procedure. It has become proverbial, for do we not say, when speaking of a loss of a very painful nature befalling a person, 'That is an eye-tooth'? During the Dark Ages, in the dungeons of feudal Barons, offending serfs and persons of even higher class had their ears and tongues and *teeth* removed as a punishment and torture; and we are, we believe, not without record of similar proceedings in the chambers of the Inquisition.

There is thus ample historical evidence, did we require it, to prove that the forcible evulsion of our organs of mastication is accompanied by such a degree of pain as to put it in the category of torture.

Accordingly, when civilization dawned upon us, and our digestive organs became simultaneously impaired, painful affections of the teeth arose, calling for their removal on purely humanitarian grounds, at first by any good Samaritan, but later by a special class of men, who became known as 'dentists,' which has evolved itself into the dental profession of the present day.

Called upon to constantly carry out this exceedingly painful operation on their fellow-men, women, and children, it is not to be wondered at that some of the profession, perhaps endowed with a greater love of their fellows than others and a spirit of research, set themselves to find

some substance capable of allaying or completely abolishing the suffering which they were unavoidably causing. Such men were Horace Wells, Morton, Riggs, and Evans, the pioneers of anæsthesia in dental surgery.

The Discovery and Demonstration of the Anæsthetic Properties of Nitrous Oxide.

A romance could be written about nitrous oxide, which Joseph Priestley discovered as a chemical compound in 1776. He was given to inhaling all sorts of vapours; he was the first to inhale oxygen, and, of course, he inhaled nitrous oxide.

It is, however, to Humphry Davy—who began life as an apprentice to Mr. Borlase, a medical man in Bodmin, Cornwall, and who afterwards went to be an assistant in his pneumatic establishment at Bristol to Dr. Beddoes—that we owe the remarkable researches on this substance, carried out for a period of two years, and published in 1800, when Davy was only twenty-two. With nitrous oxide Davy experimented on plants, animals, and men, among the last being the poets Coleridge and Southey.

It was in 1799 he first inhaled gas himself, 'when cutting one of the unlucky *dentes sapientiæ*.' After three or four doses of nitrous oxide the pain, which was very severe, diminished. In 1810 he

published an account of his observations on nitrous oxide. Nothing, however, which could be designated conclusive in its relation to surgery resulted from Davy's work. He merely remarked that 'nitrous oxide may probably be used with advantage during surgical operations.' The surgical profession of his day, however, were sceptical, and did not think the thing worthy of their attention.

The modern practice of anæsthesia, though it may have been benefited indirectly by these experiments and observations, was not the immediate outcome of them; it originated to a large extent independently, and nearly half a century passed by before anyone attempted to utilize nitrous oxide for anæsthetic purposes.

The Introduction of Nitrous Oxide into General Use.

One winter's night in December, 1844, a number of the inhabitants of Hartford, Connecticut, U.S.A., were assembled to hear a lecture on the 'Chemistry of Nitrous Oxide and Other Gases' by Dr. Colton, a well-known popular lecturer. In addition to describing their constitution and properties, he tried the effect of the inhalation of the first-named gas on some of the audience.

Among the people present were Horace Wells

and his friend John Riggs, both dentists of the city. They were astonished to see that one of the persons who inhaled the gas apparently felt no pain from a severe injury he sustained to one of his legs while capering about the hall when partially recovered from its influence.

Wells was so impressed with this fact that on the following day he begged Dr. Colton to allow him to inhale some of the gas, and while under its influence he had one of his molars extracted quite painlessly. On regaining consciousness and realizing what had been done, he exclaimed, 'A new era in tooth-pulling!' Wells was so favourably impressed with his own experience that he immediately proceeded to give the gas to his own patients, and did so to more than a dozen with complete success. Elated with his good fortune, he readily obtained leave to make a public demonstration of the method of employing gas at Massachusetts General Hospital. Unfortunately, the bag and face-piece were removed too soon, and in the extraction of the tooth the patient uttered a piercing cry. The audience, already inclined to be sceptical, hissed and hooted loudly, and Wells was laughed at as an ignorant pretender. Being a modest and rather sensitive man, he felt the insult deeply, and went home mortified and disgusted. Both he and Riggs continued to use

the gas in their private practice, but never again attempted a public demonstration. His claims to being the discoverer of modern anæsthesia were ignored, and, indeed, we are only now beginning to do his memory justice.

He never attempted to make a secret of his discovery, nor to use it for selfish ends.

His failure to convince the public of the genuine nature of his discovery, and to bring the gas into general use, so preyed on his mind that in a few years he fell ill and retired from his profession. He gradually became more and more unsettled in his mind, and finally made an end to himself in a pathetically appropriate manner by inhaling ether to excess in January, 1848.

A handsome monument, with a statue of Wells, has been erected at Hartford, and on it is the following legend:

HORACE WELLS,
WHO DISCOVERED ANÆSTHESIA,
Dec. 10th, 1844.

With Wells, for the time being, the use of nitrous oxide as an anæsthetic died out, and the discovery was again in danger of being lost.

Dr. Colton for some years tried his utmost to bring it into general use, but his efforts were quite futile until 1863, when he succeeded in getting a few dentists to try it.

After this it was largely employed by the dental profession in U.S.A., and in 1867 Colton came to Paris to read a paper on the gas, recording upwards of 20,000 administrations without a single mishap.

The Paris faculty were not enthusiastic, but in the spring of 1868 Dr. Evans, a very fashionable American dentist resident in Paris, came to London, and most successfully demonstrated the usefulness of nitrous oxide before the staff of the Dental Hospital, so that since then it has come into universal use.

The Discovery and Demonstration of the Anæsthetic Properties of Ether.

In 1818 Michael Faraday found that the effects following the inhalation of sulphuric ether were like those produced by nitrous oxide, and Sir Thomas Watson recorded how his patient, Lady Martin, felt 'as if going to heaven in a most heavenly way' when inhaling it for some chest affection.

A year later William T. Morton was born in Charlton, Massachusetts. In 1843 he qualified as a dentist and M.D., and entered into a successful practice in Baltimore. Fired with the same ambition as his partner, Horace Wells, he made attempts to extract teeth painlessly with the assistance of drugs and even hypnotism. In

December, 1844, after Wells' failure with N_2O, he wisely abandoned this agent, and investigated another which promised better results. He first tried chloric ether, which, as we shall find later, was the substance Simpson started with, but failing to get good results, and at the suggestion of Jackson, a very skilful chemist in Boston, he proceeded to try the effect of sulphuric ether. His first experiments were made on animals, and were so encouraging that he believed he had at last found the desired agent, provided the effect on human beings corresponded with that on dumb creatures. He boldly made experiments on himself, and on September 30, 1846, inhaled ether from a handkerchief while shut up in a room and seated in his own operating chair. He speedily lost consciousness, and in seven or eight minutes awoke in the possession of one of the greatest discoveries that had ever been revealed to suffering humanity. We can picture the man gradually awakening in his chair, first to the consciousness of his surroundings, and then to the consciousness of his great achievement.

First Use of Ether in General Surgery.

On October 16, 1846, the first surgical operation was performed under ether. The scene of this memorable event was the Massachusetts General

Hospital, Boston, U.S.A. Early in October of that year Morton called on the senior surgeon of the hospital, Dr. Collins Warren, and asked that a means of preventing pain in operation which he professed to have discovered might be tried in a surgical case. Warren, having made inquiries as to the method proposed and its freedom from danger, invited Morton to put it to the test on Friday, October 16. On the eventful morning a large number of doctors assembled in the theatre. Morton was somewhat late, having been detained by some difficulty in getting a suitable inhaler. The spectators, sceptical enough to begin with, not unnaturally became still more so when it appeared as if the champion of the new invention dared not show his face in the lists. After waiting fifteen minutes, Dr. Warren said with significant emphasis: 'Dr. Morton has not yet arrived; I presume he is otherwise engaged.' The remark was followed by a derisive laugh, and Warren was on the point of commencing the operation when Morton entered the theatre. His reception was the reverse of encouraging, Warren saying to him coldly: 'Well, sir, your patient is ready.' The young dentist proceeded to administer the ether, and in a few minutes the patient was unconscious, whereupon Morton said quietly to Warren: 'Your patient is ready, sir.' The surgeon's knife did not

awaken the patient from the deep sleep into which he had been passed, and the spectators looked on with wonder deepening into stupefaction. When the operation was over, Dr. Warren said in a solemn voice: 'Gentlemen, this is no humbug!'

The news soon spread to Europe, and the first administration of ether to induce anæsthesia in England took place on December 19, 1846, at 24, Gower Street, London, the house of Dr. Booth, to whom the news of Morton's discovery was communicated by Dr. Bigelow, of Boston. On the 22nd of the same month Liston amputated a limb under ether in the University College Hospital, and so intense was the emotion of the great surgeon on this occasion that, when he turned to address the spectators after the operation, he could hardly speak.

Failure of Morton to patent Ether, and his Death.

Morton endeavoured to keep the nature of his discovery secret, and to patent it under the name of 'Letheon.' In this, however, he failed, and the exact nature of the agency was only kept secret for a very short time. The characteristic smell of ether, so familiar to all the medical profession even at that time, soon betrayed its character.

Morton cannot be said to have derived much

benefit from his discovery himself. He certainly received several honours and presents, but his fruitless endeavours to obtain State recognition of a monetary nature, together with prolonged squabbles and controversies concerning his discovery, worried him into a state of ill-health, and very soon into an early grave.

The Invention of a Suitable Inhaler for Ether.

Joseph Thomas Clover was born at Aylsham, Norfolk, in 1825. After being apprenticed to a Norwich surgeon, he entered University College, London, where he distinguished himself as a student. In 1853 he began practice in London, and became an F.R.C.S. His natural inclinations were in the direction of surgical practice, but repeated attacks of ill-health made him confine his attention to anæsthetics. It has been said of him that it was a matter of doubt whether the art of surgery lost or anæsthesia gained the more by this. He was a man full of ingenuity and resource. His inventions were numerous, and he was a pioneer in the modern art of anæsthesia. His name will be perpetuated by his ether inhaler, which since he brought it out in 1877 has always been, *facile princeps*, the best apparatus with which to administer ether for dental purposes.

The Introduction of Chloroform.

While the discoverer of ether was wasting his time and money in dispute concerning priority, and Wells was dying from chagrin and inaction, a bolder and higher type of man than either had taken up the work where they had left it, with the high object of pursuing it until he had for ever established the benefit to humanity which he recognized in it. This man was James Young Simpson. He was born at Bathgate, in West Lothian, in 1811. He entered the University of Edinburgh in 1828, where he had a very distinguished career as a student, and took his M.D. degree in 1832. In 1840 he was appointed to the Chair of Midwifery after a severe struggle. Placed in this position at the age of twenty-nine, Simpson soon showed himself highly qualified for it. His lecture-room was thronged by eager students. His fame quickly spread, and patients came to him from every part of the world. He was one of the first to call attention to the evils of 'hospitalism,' and he suggested that a separate system should be adopted for patients, instead of aggregating them in crowds in disease-tainted wards. When anæsthesia came before the world, Simpson at once gave his mind to the subject. He was the first (January, 1847) to apply ether to

the mitigation of the pains of childbirth. Not being quite satisfied with that agent, for want of proper apparatus for its administration, he set to work to discover some other anæsthetic free from what he considered its drawbacks.

Dangerous Experiments with Chloroform.

He tried a number of different substances on himself, and more than once came near falling a martyr to his zeal for knowledge. At last, acting on a hint from David Waldie, a Liverpool pharmacist, he tried chloroform. He was not aware that early in 1847 a French chemist—Flourens—had drawn attention to its effect on animals, or he would not have put away untried the first specimen sent him, as it appeared to him heavy and non-volatile, and seemed unlikely to be an efficacious anæsthetic by inhalation.

However, late one evening early in November, 1847, on returning home after a heavy day's labour, Simpson and his two friends and assistants, Drs. Matthews Duncan and George Keith (who is still alive), sat down to their somewhat hazardous experiments in Simpson's dining-room in Queen Street, Edinburgh. After inhaling several substances without much effect, it occurred to him to try the neglected specimen of chloroform. All three charged their tumblers with the drug, and

began to inhale it. Very soon an unwonted hilarity seized the party; they became bright-eyed and very loquacious, expressing their high approval of the aroma of the fluid.

Their conversation was of quite unusual intelligence, and quite charmed the friends who were watching their experiments. But suddenly their voices became louder, their expressions exclamatory, then unintelligible. A moment more and all was quiet, and then there was a crash.

On awakening, Simpson's first perception was mental. 'This is better and far stronger than ether,' he remarked. He then noted the fact that he and his two colleagues were prostrate on the floor. Dr. Duncan, with his eyes staring and his jaw dropped, was snoring in an alarming manner, while Dr. Keith, partially awakened, was making vigorous attempts to kick over the supper table! In a few minutes all three completely regained their consciousness and seats, and each expressed his delight with the new agent, which they again repeatedly inhaled.

The following morning Mr. Duncan, of Duncan and Flockhart, was pressed into their service to prepare a large supply of the drug, and Simpson made an immediate trial of it in his midwifery practice, with such success that on November 10, 1847, he read before the Medico-Chirurgical

Society of Edinburgh a paper entitled 'Notice of a New Anæsthetic Agent as a Substitute for Sulphuric Ether.'

Professor Miller sent for Simpson a few days after the discovery of chloroform to ask him to give it to a patient on whom he was about to perform a major operation. Simpson was, as luck would have it, prevented from attending, and Miller began the operation without him. At the first cut of the knife the patient fainted and died.

Had chloroform been administered, one can readily imagine what a blow this untoward event would have been to Simpson and to the cause of anæsthesia.

Subsequently, however, he gave it with great success to patients of Professor Miller and other of his colleagues, while in his own obstetric practice he used it as a matter of routine, and there is no doubt that the kudos he gained among the fair sex from being the first to mitigate the pains of labour added vastly to his already growing reputation.

Chloroform soon came into general use in this country in place of ether, and the word itself became so common in the vernacular that the people began to recognize it as synonymous with and more expressive than an anæsthetic. It may have been this fact that led Simpson in the

'Encyclopædia Britannica' to deal with the subject of anæsthesia under the heading 'Chloroform,' but a less charitable interpretation was placed on his conduct by our American cousins. There can be no doubt, however, that to Simpson belongs not only the honour of introducing chloroform, but the merit of popularizing anæsthesia both with the profession and with the public. His energetic advocacy bore down all the opposition that ignorance, superstition, prejudice, and scientific jealousy mustered against it. His name will long live, not only as the introducer of chloroform, but as the reformer of obstetric medicine, which he found the despised art and left an honoured science.

The idea prevailed for some time that $CHCl_3$ was absolutely safe, but the death of a young woman named Hannah Greener, on January 28, 1848, at Alloa, while being operated on for an ovarian tumour, Simpson himself acting as chloroformist, soon showed that it was an erroneous one. From time to time similar casualties occurred, and it soon became obvious that, whatever advantages the new system of inducing insensibility might possess, the administration of chloroform was by no means without grave risks to life.

As death after death was reported, every conceivable and inconceivable theory was advanced

to explain them. The most deplorable ignorance, however, prevailed, and several years went by before any satisfactory light was thrown on their causation.

The Introduction of Ethyl Chloride as a General Anæsthetic.

The career of ethyl chloride as a general anæsthetic has been almost as chequered as that of nitrous oxide, for it has taken upwards of half a century to establish its position and gain the confidence of the medical and dental professions.

In 1848 Heyfelder first employed the drug to induce general anæsthesia in the human subject. For a number of years after that, however, ethyl chloride remained entirely in desuetude, although several observers commented favourably on its value. In 1867 B. W. Richardson experimented with it, and found it ' a good and safe anæsthetic ' ; but his remarks do not seem to have attracted the notice of the profession, and we do not find any record of the practical use of this drug for a period of nearly thirty years after this. In 1896 Carlson, the Director of the Dental Institute in Gothenberg, showed that in certain cases where local analgesia of the gums was produced by means of the ethyl chloride spray, the patient became quite uncon-

scious. He rightly concluded that this was due to inhalation of the ethyl chloride vapour.

Thiesing Billeter and other Continental surgeons and dentists then employed it as a general anæsthetic with good results, and during the next few years several thousand cases were recorded, and favourably commented on in the foreign medical and dental journals.

In 1902 McCardie of Birmingham began to use the drug, and in March of that year published an article in the *Lancet* drawing attention to its value as a general anæsthetic agent. Subsequently he published several other papers with series of cases, and it was primarily due to his advocacy that ethyl chloride was taken up in this country.

About the same time demonstrations of an anæsthetic nostrum known as 'somnoform' (consisting for the most part of ethyl chloride) were given at various dental hospitals throughout the country, and there is no doubt that these attracted to a great extent the attention of the dental profession to the matter. The market was speedily flooded with all kinds of proprietary preparations under fanciful names, but actually consisting of ethyl chloride and nothing else, while in a short time inhalers innumerable, suitable and unsuitable, were introduced for ad-

ministering the drug. Ethyl chloride was, for some four years (1901–1905), administered broadcast by all and sundry, and this would constitute a most trying test for any anæsthetic whatever; yet comparatively few deaths have been actually recorded—about a score—though there can be little doubt that some more have occurred which have not been brought to light. Be that as it may, one can have no doubt that in ethyl chloride we have a most valuable anæsthetic agent for dental surgery.

Twentieth-Century Anæsthesia.

Excluding the introduction of ethyl chloride, the present century has been responsible for many and very important advances. On the surgical side, the administration of ether by *open* methods, either by dropping the drug upon a mask covered with gauze, or by pumping the vapour through a tube delivering its contents under such a mask, has done much to popularize ether for major surgical work, while the work of Meltzer upon the intratracheal method of anæsthetizing has placed in our hands a most valuable weapon for assisting certain surgical work. Upon the dental side, which more immediately concerns us, the most striking development is seen in the perfection of methods for administering nitrous

oxide gas with known and controllable percentages of oxygen. United as it has been with much ingenuity in devising suitable apparatus, the combination of nitrous oxide and oxygen is now largely employed by the nasal route, enabling the anæsthesia to be prolonged indefinitely without hampering the work of the dentist.

CHAPTER II

THE CHOICE OF THE ANÆSTHETIC FOR DENTAL OPERATIONS

There are four factors to be considered in making the choice, viz.—(1) The patient, (2) the operation, (3) the operator, and (4) the person who administers the anæsthetic.

1. The Patient.

The age of the patient is the primary consideration, and with children and old people we shall deal fully elsewhere. For young healthy adults and middle-aged people nitrous oxide gas is best adapted if a brief anæsthesia only be required.

Sex has little influence on our choice, but the position in life of the patient has a considerable influence on behaviour under an anæsthetic. Thus, if we exclude hysterical women and alcoholics of both sexes, members of the upper and middle classes take anæsthetics quietly, generally speaking, and regain consciousness without any undue display of the emotions.

'The masses, whose emotions and instincts

are undisciplined, and who have never practised any degree of self-control, or experienced any control, parental, sacerdotal, or magisterial—who are, in short, uneducated, though they may have passed through a course of elementary instruction—will often resist, scream, swear, kick, and otherwise misconduct themselves during the administration and after the recovery. Alcoholics, loose women, and football-players, when gas and ether or gas and ethyl chloride are being administered to them, should be brought more fully under the gas before the ethyl chloride or ether is introduced than would be necessary in the case of less excitable patients. The state of the patient's health is important, but does not require very long consideration here, because if the patient is fit for the operation he is fit for the anæsthetic. No doubt there are many conditions in which the administration of the anæsthetic is attended with grave risks, and must give rise to anxiety. This may be truthfully said, for instance, of acute intestinal obstruction, depressed fracture of the skull, the terminal stages of exhausting diseases, or of dyspnœa from the narrowing or obstruction of respiratory passages by the presence or pressure of growths. But patients exhibiting these conditions are seldom sent to have their teeth extracted under anæsthetics.

There are many conditions which call for care and skill on the part of the anæsthetist. Advanced atheroma, chronic bronchitis, Bright's disease, advanced phthisis pulmonalis, valvular disease of the heart, especially with failing compensation, aortic aneurism, pernicious anæmia, and diseases of the central nervous system are a few of these' (Guy).

2. The Operation.

If one or two teeth only require to be extracted, nitrous oxide is the best anæsthetic, unless there be some contra-indication, from being most usually available.

If there be five or six teeth of uncertain difficulty to extract, the choice will lie between continuous gas administration by the nasal method (with or without admixture with oxygen) and a mixture of nitrous oxide oxygen and ethyl chloride.

If there be a greater number of teeth or a very difficult tooth, such as an impacted wisdom, then gas and ether or ethyl chloride and ether sequence should be used.

3. The Operator.

Where the operator unfortunately requires to fulfil the double function of operator and anæs-

thetist, he has to calculate the time he will need, and gauge his own dexterity as an extractor. On the other hand, if, as should always be the case, a separate individual act as anæsthetist, his proper course is to ask the dental surgeon who is to operate what time he thinks it likely he will require, and then choose his anæsthetic accordingly. The anæsthetics at his disposal are the following: Nitrous oxide gas, ethyl chloride, gas and ethyl chloride sequence, nitrous oxide (nasal method, with or without admixture with oxygen), gas and ether sequence, ethyl chloride and ether sequence, ethyl chloride and C.E. sequence, C.E. and ether sequence, and local anæsthesia. The available anæsthesia with these will be somewhat as follows:

Nitrous oxide	35 seconds.
,, ,, and eth. chlor. ..	90 to 120 seconds.
,, ,, and oxygen ..	90 to 120 seconds.
,, ,, (nasal method) ..	1 to 5 minutes.
,, ,, and oxygen (nasal method)	indefinite
,, ,, and ether ..	1 to 10 minutes.
Ethyl chloride	1 to 2 minutes.
Ethyl chloride and ether ..	1 to 10 minutes.
Ethyl chloride and C.E. ..	2 to 5 minutes.
C.E. and ether sequence ..	3 to 10 minutes or *ad lib.*

4. The Anæsthetist.

The person responsible for the anæsthetic will be influenced by various considerations. In a

dentist's room or at a hospital, gas or gas and ether will receive his first consideration, but if the operation is to be done at the patient's house, and possibly at a distance, the greater portability of ethyl chloride will influence him in its favour. We are now supposing that the administrator is familiar with all the anæsthetics which we have enumerated, but, unfortunately, this is frequently very far from the case; indeed, when the individual in question is a country practitioner, his experience is restricted in most cases to two anæsthetics, generally chloroform and ether; too often, north of the Tweed, to chloroform alone. Guy says: 'In the latter case, I think it is the duty of the dentist to state very plainly to the doctor his preference for some other anæsthetic than chloroform, to insist on the operation taking place elsewhere than at his house (if chloroform be used), and to make it clear that he disclaims and is absolved from any responsibility for any untoward result.' With this expression of opinion the author is entirely in accord. Elsewhere his views are stated on this question *in extenso*.

Anæsthetics in Special Cases.

Children.—Children of tender years are by no means good subjects for nitrous oxide. It is often well-nigh impossible to maintain a satisfac-

tory anæsthesia for anything but the shortest dental operation in a child under seven years of age by means of this anæsthetic, the difficulty increasing the younger the child is. In the first place, we have all a dread of the unknown, and in children this is especially the case; the apparatus looks formidable, and may terrify the little patient.

Again, it is difficult for the dentist to operate so rapidly as on an adult, for the mouth is small and the forceps large, while there may be cyanosis and spasm, jactitation, and not uncommonly screaming on the patient's part. In this connection, it is often very difficult to persuade the friends who may be present that the child has felt nothing, for the crying and jerking of the body and limbs seem to the uninitiated to be the outward and visible manifestation of a painful sensation.

While children do not take pure nitrous oxide well, owing to their liability to convulsive movement, they react very favourably to nitrous oxide and oxygen if once they can be induced to submit to the application of the mask. With an intelligent self-controlled child, even nasal gas and oxygen is quite feasible, but is rarely called for. If the administrator is not well versed in nitrous oxide and oxygen, he will be wise to

consider the use of ethyl chloride rather than pure nitrous oxide.

The degree of success which is attained with this class of patient will largely depend on the tact and patience of the person conducting the administration. His patience and powers of persuasion will in some cases be strained to the utmost, often not more by the child, however, than by a foolish and doting parent. It is useless to lose one's temper in any case, and perseverance in this, as in most things, will win the day.

If the insertion of the mouth-prop be much objected to, the administration may be commenced and a prop slipped in when the sensibilities have become somewhat duller, or a mouth-opener be used when complete anæsthesia has been established.

Patients who are advanced in Years.—Patients over sixty years of age, if in good health, usually take nitrous oxide well; they pass quickly under its influence, and though cyanosis is rather marked, the anæsthesia is long in duration, and profound compared with young adults. The addition of oxygen to the nitrous oxide will in all cases be found advantageous. In dealing with such patients, it must be remembered that they are probably the subjects of senile changes in the way of thickened and brittle arteries, feeble hearts and diminished respiratory power.

Special watchfulness is needed, and the possibility of apoplexy, if nitrous oxide be pushed, is to be borne in mind (see Chapter IX.).

The presence of ' winter cough ' or chronic bronchitis should be inquired after, and, if the patient suffers in this way, ether should be avoided or given sparingly. The gas and ethyl chloride sequence, or ethyl chloride alone, is well suited to people of advanced years.

Heart Disease.—Although nitrous oxide is by no means contra-indicated in cardiac disease, all such cases should be treated with additional care, and the anæsthetic be given by an expert anæsthetist or in the presence and with the help of a fully-qualified medical man. To satisfy the patient, at least, it is well that the physician should feel the pulse at the wrist before starting the anæsthetic, and in some cases the preliminary administration of a little brandy or other alcoholic stimulant is of value. The cyanosis often becomes marked at an early period of the inhalation, and the pulse (which should be kept under observation throughout the administration) becomes slower; if any sign of intermittence is noticed, the gas should be immediately withdrawn. All these difficulties disappear with the admixture of oxygen.

Ethyl chloride and ethyl chloride and ether may be given with safety.

Pulmonary Disease.—Patients suffering from any pulmonary affection are not good subjects for any anæsthetic, particularly if there be any tendency to dyspnœa; the emphysematous and bronchitic take nitrous oxide badly, often becoming intensely livid, and they may succumb from heart failure, for their blood is inefficiently aerated, and the right side of the heart is already overloaded. Patients suffering from tubercular disease of the lungs also require special consideration and careful treatment. When there are large cavities in the lungs in advanced years, the loss of breathing space impedes the action of the gas, while in all cases early and late hæmoptysis may be brought on by the administration of nitrous oxide and ether.

Further, if chloroform be given, these patients often give trouble during the anæsthesia, and make a bad recovery, suffering from vomiting, and giving evidence of general systemic depression for days.

If, therefore, chloroform be employed for some special reason, it should be administered along with oxygen, for this combination gives a much better type of anæsthesia, and the after-effects are usually very slight.

Unless this course be adopted, the alternative one is, if an extensive extraction be required, to have several sittings, and to remove three or four

teeth at a time under gas and oxygen anæsthesia. Even if nasal gas and oxygen be available, it is wise not to attempt too much at one sitting. The necessity for these precautions should be carefully explained to the patient.

Further, the greatest possible care should be taken to sponge thoroughly and maintain oral asepsis while the gums are healing, so as to prevent any secondary infection of the lung of a septic nature, which, if it supervened, would place the patient in a position of great jeopardy.

Nervous Disorders.—Epileptic and choreiform seizures are recorded as having been induced by the inhalation of nitrous oxide and other anæsthetics. The author has seen several such cases when gas was being administered, but they are not of sufficiently frequent occurrence to warrant refusing to administer gas to persons who are subject to epileptiform or choreic attacks.

Cases of insanity and mental aberration following artificial anæsthesia have been recorded. Savage has drawn special attention to this question (*British Medical Journal*, December 3, 1887). We have personally known of two patients suffering from temporary delusional insanity after inhaling nitrous oxide. Such incidents are probably comparable to those seen in men who have been underground during or after an explosion in a coal-mine,

and are explained by Haldane as being the result of prolonged sub-fatal oxygen deprivation.

Although on theoretical grounds ether is known to tend to cerebral congestion and mental excitement, there seems to be no contra-indication to the use of gas and ether, or ethyl chloride and ether, for a brief anæsthesia such as is required for dental work among persons who are mentally afflicted. Guy, who has a large experience among this class of patient, is of this opinion, and the author is in agreement with him.

As regards *hysteria*, women who are not prone to hysterical manifestations not uncommonly give signs of them when recovering from nitrous oxide or ethyl chloride, and, of course, the tendency is more marked in 'hysterical subjects.' A little tact and firmness, however, is all that is necessary in dealing with such patients. Their noisy lamentations, and sometimes cataleptic condition, may often be very trying to the busy dentist. The windows should be opened wide, a wet towel applied to the forehead, strong smelling-salts used, while sympathizing friends are removed from the room, and they and the patient from the house as soon as may be. The advice to remove sympathizing friends must not be construed as indicating that the dentist should empty the room of all its occupants save the patient and

himself. Hysterical women recovering from short anæsthesias are apt to dream dreams of an erotic type, and to believe (with how much conviction it is impossible to say) that they have been the recipient of improper attentions from the man who administered the gas. Bearing this in mind, the dentist will not lightly consent to administer gas and extract a tooth from a lady upon whose honesty of thought he does not feel he can rely, unless a witness, preferably female, is also present.

Pregnancy.—Nitrous oxide may be administered with safety to most patients up to within a month of full term, but care must be taken to avoid pushing the gas and inducing marked clonic contractions. If the patient is very nervous and anxious about the matter, or if she is almost at full term, it will be wiser to substitute the gas and ethyl chloride sequence (or ethyl chloride alone) for nitrous oxide, using every possible precaution.

Alcoholism and Drug Habits.—Patients who are given to the injudicious use of alcohol, and to the use of cocaine and morphia, are disposed to be unusually troublesome during artificial anæsthesia, and it is well to be on one's guard in dealing with them. With alcoholic patients struggling is always to be expected, and may be very violent and troublesome.

Several assistants may be required to restrain

the patient, and all glasses, mirrors, jugs, and trays of instruments should be placed in the background in case of accident.

In the case of morphia maniacs, especially if they have recently had an injection, quite a small amount of anæsthetic may suffice, and care is necessary not to push it too far.

Tobacco Habit.—It is well known that persons addicted to the excessive use of tobacco take anæsthetics badly as a rule. The inveterate pipe-smoker has hypertrophied muscles of mastication. The mucous membrane of his nose, mouth, and pharynx is injected and often œdematous; his uvula is often elongated and swollen, resting on the dorsum of the tongue; and his air-way is thus narrowed. His mucous and salivary glands become larger and more active, and hence the increased salivary secretion. The heart may be dilated and sounds soft; the pulse weak and sometimes irregular. Ether often seriously increases the injection and œdema of the respiratory tract, and sets up a series of spasms, with excessive secretion of mucus, etc.; after a good deal of coughing, the patient becomes lightly anæsthetized, yet his face is livid, and he is half choked by the swollen mucous membrane and retained secretion. The pale, anæmic youth, who smokes an excessive quantity of cigarettes, besides possess-

ing the abnormal respiratory tract of the pipe-smoker, shows evidence of thickening and irritation of the bronchial mucous membrane caused by inhalation of the smoke, which in all probability in some cases actually damages the lung-tissue. In the cigarette-smoker, also, the nervous changes are more marked than in the pipe-smoker. The former is highly strung, nervous, and irritable, and is apt to get fainting attacks. The knee-jerks are increased, ankle clonus sometimes present, and fine tremors of the hands very obvious. When nitrous oxide is administered much is needed; the breathing is shallow in character and struggling is of common occurrence.

Ether causes great irritation of the already irritated mucous membrane of the trachea, bronchi, and perhaps even of the alveoli, and probably spasm of the bronchial muscular coats. Moist râles may be heard over the back and front of the lungs, like those of acute bronchitis. The induction of ether or ethyl chloride ether anæsthesia is often unpleasant, and even impossible in some cases.

If the insertion of the mouth-prop causes retching, as it often does, this may be overcome in most cases by rinsing the mouth out with a weak solution of carbolic acid (1 : 100). The combination of oxygen with the gas will greatly lessen the

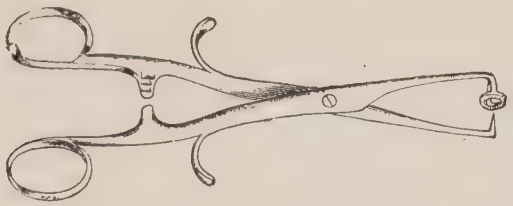


FIG. 1.—THOMSON'S TONGUE FORCEPS.

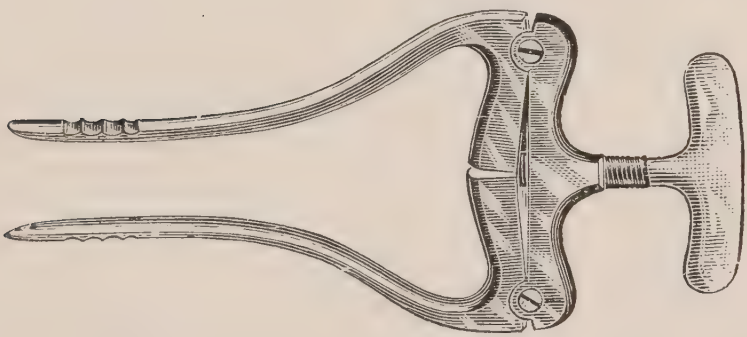


FIG. 2.—HEISTER'S MOUTH-WEDGE.

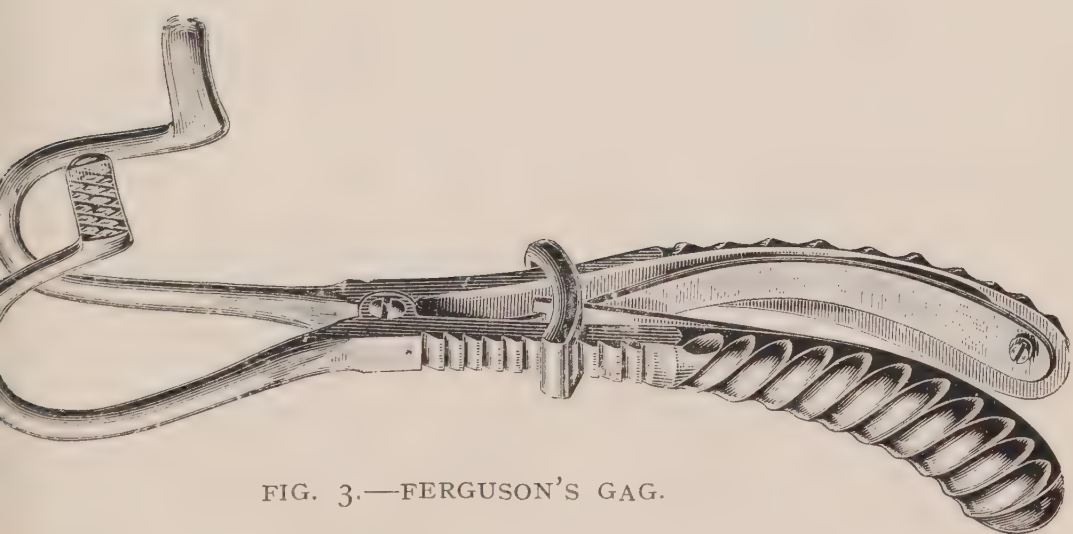


FIG. 3.—FERGUSON'S GAG.

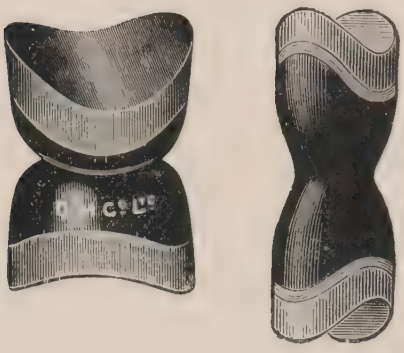


FIG. 4.—VULCANITE PROPS.

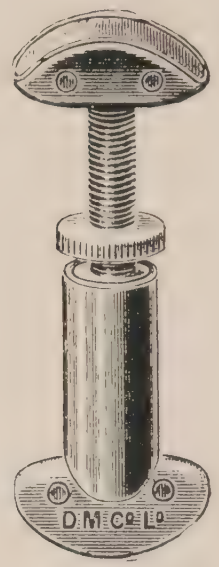


FIG. 5.—TELESCOPIC PROP.

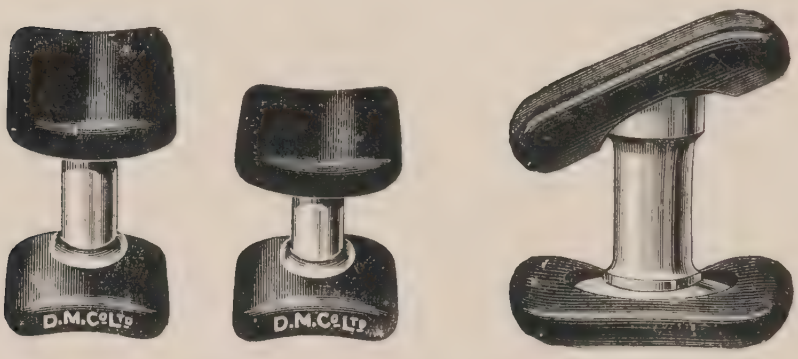


FIG 6.—HEWITT'S PROPS.

FIG. 7.—GUY'S MOUTH-PROPS.

cyanosis and jactitation. In some cases the use of chloroform and oxygen will be preferable, and even necessary, rather than ether. If ether is employed, however, the previous injection of $\frac{1}{100}$ grain of atropine will be of great use to prevent excessive secretion.

Certainly in connection with alcoholics and drug-takers, and probably in connection with heavy smokers, it is now certain that most of the abnormal phenomena seen are, to use a modern term explained in a later chapter, *anoxæmic* in origin; in other words, the tissues, especially the nerve tissues, are short of oxygen, the carrying power of the blood in that respect having been damaged by the particular toxin to which the individual has accustomed himself. This theory is strongly corroborated by clinical evidence. If care be taken in these cases to guard against any undue deprivation of oxygen, unfavourable symptoms are markedly reduced in violence.

Accessory Apparatus required in Anæsthesia for Dental Operations.

Among these may be specially mentioned the following:

1. Instruments for opening the mouth and keeping it open, such as gags and props.

2. Tongue forceps.

3. Sponge holders.

4. Hypodermic syringe and solution of strychnine (1 : 100).

5. A bib or apron for the patient, to prevent soiling of the clothes.

6. Some sponges of *coarse* texture, or pieces of gauze which can be rolled up to make 'swabs.' The 'aseptic tampons,' tightly rolled in an outside cover of muslin, are practically useless for sponging.

Of gags, there are many kinds. The best one, generally speaking, for dental work is that of Ferguson or Dudley Buxton, with good long handles which allow of a considerable amount of purchase. Croft's gag finds favour with some people, but the handles do not allow of sufficient purchase, if the patient has a strong jaw or if there is any tendency to masseteric spasm.

The essential points to look to in selecting one are the length of the handles; the tooth-plates of the gag (which should come close together, or lie in the same plane as in Buxton's); a ready means of fixing the gag in any degree of extension; an easily-working joint; and, lastly, good, all-forged blades throughout. A little dexterity in using a gag is readily acquired when once its mechanism is understood, and quickness of application is essential to its successful employment.

As regards *mouth-props*, the most generally useful are the simple ebony or vulcanite ones, with their surfaces padded with indiarubber. Hewitt's pattern and Gardner's, both made of aluminium, are good, but rather too large for use on young children. Some men prefer to use spring gags, such as Buck's; but, generally speaking, these should be avoided, as the spring is very apt to get out of order, and sometimes the two parts of the gag separate at an awkward moment. Further, the adjusting part looks, and *is*, difficult to clean, so that a fastidious patient may object to using it. The following are the chief points to have regard to in the selection of a mouth-prop:

1. It should be made of hard material, not likely to split or chip, so that it may be scrubbed frequently. The dental surface should be fitted with pads of rubber or some non-absorbent substance.

2. It should be as small as is compatible with strength, or it will be in the operator's way.

3. It should be all one piece, as joints are apt to give way.

4. A strong piece of catgut, silk, or whipcord 10 to 12 inches long should be tied firmly round the stem, and attached to another prop, so as to do away with any chance of the prop going down

the patient's pharynx. The string requires frequent renewing, as it soon gets blood-stained and soiled. The best material of all is a light but strong metal chain.

A cork properly shaped with a sharp penknife, and tied to a string, makes quite a good emergency gag, but can only be used once or twice. A little care expended on the insertion of the mouth-prop well repays the operator. The prop should always lie quite straight, and be held firmly in the bite. If possible, it should never be placed further forward than the bicuspid teeth, or the masseteric spasm set up during the anæsthesia (if gas or ethyl chloride be used) may be so great as to force out one of the incisors or canines. If it has to be placed far forward, it should be put between the incisors, and a prop broad enough to overlap two teeth should be employed.

Inhalers recommended for Ordinary Practice.

Opportunity will arise, as we discuss in a later chapter the individual anæsthetics, to indicate to the reader the exact type of inhaler which he will, in the author's opinion, find most generally useful. We may, however, at this stage lay

down some general rules as to the type of apparatus which should be provided respectively by the dentist or the medical man who gives anæsthetics for dental purposes.

Taking first the dentist, he will certainly need a substantial stand for nitrous oxide cylinders of 50 or, preferably, 100 gallon capacity, and a Barth or Hewitt's nitrous oxide apparatus with three-way stop-cock and a 2 or 3 gallon bag (see pp. 60, 61). If he proposes to administer anæsthesias more prolonged than can be attained by these simple devices, his choice will lie between a Guy-Ross nitrous oxide-oxygen-ethyl chloride apparatus, as shown in Fig. 29, or one of the nitrous oxide-oxygen apparatus with nasal attachment referred to in Chapter VII., pp. 168-170. He may or may not choose to add to his set a Clover or Hewitt ether chamber (see p. 125, *et seq.*).

The medical man should certainly also possess what one may term the rudimentary appliance—namely, a Barth or Hewitt face-piece, valves, and bag. The exact size of cylinders upon which he proposes to rely for his supply of gas will depend upon whether he can always rely upon motor or other wheeled transport. Two 50-gallon cylinders and the necessary inhaler can be carried in a hand-bag without unpleasant effort, and

the addition of an ether inhaler makes but little difference.

If he proposes to give nitrous oxide by the nasal route without provision of oxygen from a cylinder, he will need 100-gallon cylinders of gas, and will probably choose the inhaler shown on p. 83.

Should his choice incline towards nitrous oxide and oxygen, and he does not rely upon the dentist to supply the necessary plant, he will do well to acquire Mr. Bellamy Gardner's apparatus referred to on p. 181, or that shown on p. 175.

Lastly, should he wish to give nitrous oxide with ethyl chloride, and to have available the means to add pure oxygen gas to the mixture, the Guy-Ross inhaler can be put up in very portable form, and is quite adequately served by cylinders of 50-gallon capacity both for nitrous oxide (two) and oxygen (one only).

CHAPTER III

NITROUS OXIDE

NITROUS OXIDE is in all respects, *facile princeps*, the basic anæsthetic for the dental surgeon. Properly used, it is almost entirely free from danger, and is rarely productive of nausea or even temporary depression as after-effects. Induction of anæsthesia by the agent is, to most sensible people, by no means an unpleasant experience, consciousness being lost within twenty seconds without any preliminary distress, mental or physical. Anæsthesia is usually complete within sixty seconds, and the sole drawback, from the operator's point of view, lies in the fact that the anæsthesia often lasts only for thirty seconds, and rarely exceeds forty seconds. This period, however, permits a dentist of ordinary dexterity to extract from one to five teeth or more. It is naturally essential, and only fair to the person acting as anæsthetist, for the operator to have everything in readiness for starting, before the patient begins to inhale, so that every second of the period of anæsthesia may be utilized if necessary.

In these days, to extract teeth without the use of 'laughing gas,' except in the case of the most hardy and robust men and in emergencies, is little short of barbarous. It is cruel to the patient, and if the subject is a child, wantonly so. Very few people can submit to the operation without some resistance, and though this be involuntary, the operator is handicapped by it, and from anxiety to be quick, the liability to break a tooth or portion of the alveolar plate is greatly increased.

Nitrous Oxide (N_2O). Synonyms: Protoxide of Nitrogen, 'Laughing Gas,' or Gas.

Nitrous oxide gas is a colourless body, possessing a rather sweet taste and odour, and a specific gravity of 1·527. It is neutral in reaction, and consists of nitrogen and oxygen in chemical combination, and so differs from atmospheric air, which is simply a mechanical mixture of these gases. Nitrous oxide has been proved to possess well-defined anæsthetic properties, and these are not due to simple displacement of oxygen in the blood, or to a partial asphyxia, but to the fact that the gas enters into a loose combination with the hæmoglobin in the red blood-corpuscles, and is so conveyed to the nerve centres, on which it has a specific action.

It is possible to liquefy nitrous oxide with a-

pressure of fifty atmospheres at a temperature of 7° C., and the practical and commercial importance of this lies in the fact that the gas can be readily stored in steel or iron bottles, and so conveniently carried about. Liquid nitrous oxide—specific gravity ·936—is colourless and mobile, and 15 ounces of it will yield 50 gallons of the gas. The pressure in the cylinders containing nitrous oxide often registers 1,000 pounds per square inch. The gas undergoes rapid expansion when heated in any way, and if this be done incautiously without the valve being unscrewed a little so as to allow a slight escape of the gas, the cylinder may burst.

Under very great pressure nitrous oxide will solidify, and becomes white and snowlike in appearance. When gas-bottles are lying horizontally, and the gas is allowed to escape suddenly, it often assumes the solid form, especially on a cold day, and so blocks the outlet. This sometimes gives us the impression that the bottle is empty, but a few minutes later, when the obstructing particles have melted, the gas escapes with a loud explosive report.

Nitrous oxide is prepared by heating granulated ammonium nitrate to 460° F. and collecting the gas evolved over water. The process is comparatively simple, and until recently dentists often

prepared their own gas. There are a number of impurities, however, which require removal, and, unless this is effected, they often give an unpleasant and nauseous smell to the gas, and cause irritation of the throat and respiratory passages of the patient. Accordingly, it is desirable to procure gas only from a reliable maker who carries out the processes necessary for a complete purification of the gas. There is no advantage in using freshly-prepared gas, for when stored in cylinders it keeps perfectly well. The author would, however, like to mention one apparent exception to this generally recognized rule. He was giving nitrous oxide and oxygen to a lady in a nursing home from a 'sight-feed' machine; in this type of apparatus the gases are bubbled through water in a glass container. As soon as he turned on the nitrous oxide he noticed that the water turned brown. He knew that the cylinder had been used some weeks previously and partly emptied, and presumed that a little rust had gathered round the orifice of the cylinder, and therefore paid no special attention to the discoloration of the water. It was obvious, however, after some minutes that little or no anæsthetic effect was being produced, and he accordingly turned on the gas from the spare cylinder, when anæsthesia came on so quickly

and naturally as to exclude the possibility of any abnormality on the part of the patient. Unfortunately, too little of the gas remained in the first cylinder to permit of chemical analysis. The firm who supplied the gas informed the author that they knew of no similar incident ever having occurred, and mentioned that they had in their possession a letter from a customer who stated therein that he had just used a cylinder of gas which had been in his possession *thirty years*, and found its contents perfectly effective.

The Physiology of Nitrous Oxide.

While it is very true, as explained below, that nitrous oxide is as truly an anæsthetic drug as is chloroform or ether, it is equally true that we cannot give nitrous oxide without most profoundly modifying the quantities present in the blood of the natural blood gases—namely, oxygen and carbon dioxide—and it behoves us, therefore, to say a few words upon the physiological changes which follow.

A sufficiency of *oxygen* is essential to continued life. Animals totally deprived of oxygen immediately begin to breathe quickly; there is increased respiratory exchange, but the increase is more in the rate than the depth of respiration. The pupil of the eye dilates in a very striking

manner, and within a few minutes the animal develops convulsive movements and dies. In passing, we may remark that the smaller arteries are thrown into a condition of vaso-constriction, and that there is therefore for a time a marked rise of blood-pressure. The term now applied to this condition of oxygen starvation is *anoxæmia ;* formerly it was called asphyxia, and this term is still often applied.

The entry into the circulation of nitrous oxide gas necessarily displaces a considerable part of the oxygen normally carried, since the gas combines with the hæmoglobin, in association with which oxygen is normally conveyed by the blood from the pulmonary vessels to the tissues. The blue tinge seen in the face in fully developed nitrous oxide anæsthesia is no doubt partly due to the colour of the compound formed between the hæmoglobin and the gas, but it is a mistake to forget that a certain amount of anoxæmia is present, or to flatter oneself by the belief that the patient can survive indefinitely upon the small amount of oxygen yet remaining in his blood and tissues. Moreover, the sphygmomanometer has shown us that even in ordinary nitrous oxide anæsthesia there is a marked rise of blood-pressure which, without doubt, is anoxæmic in origin (Guy, Goodall, and Reid).

On the other hand, it is equally fallacious to suppose, as did Sir George Johnson, that nitrous oxide anæsthesia was merely a 'beneficial asphyxia.'

In any administration, then, of nitrous oxide, whether alone or combined with oxygen, it is essential to bear in mind the cardinal signs of anoxæmia:

1. Dilatation of pupil.
2. Convulsive muscular movements.
3. Short, quick respirations, rapidly becoming irregular.

The appearance of (1) may be regarded as not indicating any special danger in short administrations if the pupillary enlargement be not too extreme. We often push a nitrous oxide anæsthesia to the stage where (2) is beginning to appear, but would not permit the condition to persist for more than a few seconds; while the appearance of (3) would indicate definite danger, and should be accepted as a warning that we have gone beyond the degree of anoxæmia which can be considered safe for however short a period.

Before leaving the question of anoxæmia we may remark that the proof of a real anæsthetic action of nitrous oxide as apart from the concomitant anoxæmia lies in the fact that if the gas be diluted with just enough pure oxygen to

maintain life, a perfect anæsthetic sleep can be produced without lividity or other signs of oxygen want. To this point we shall recur when dealing with the nitrous oxide and oxygen combination.

We now turn to the other active normal blood gas—namely, *carbon dioxide*. The older writers concentrated their thoughts in this connection almost exclusively upon *carbon dioxide excess*. If, as is the case in some systems of giving nitrous oxide, the patient breathes in and out of a bag containing the gas, respiring its contents over and over again, it is certain that the bag will ultimately contain a high percentage of CO_2, and when this exceeds 6 to 8 per cent., the physiological effect of CO_2 excess will be seen. The most striking phenomenon is the increased *depth* of respiration, a slight increase of *rate* only being noticed. The face assumes a congested, anxious appearance, and there is usually sweating of the forehead. The minor degrees of this condition are not dangerous to the subject unless combined with extreme anoxæmia, but even with a sufficiency of oxygen there is a point beyond which danger may arise. We are not in a position, of course, to analyze at any particular moment the contents of our bag, and to say that, for instance, because the percentage of CO_2 has passed 6 per

cent. danger is being incurred, but we have at our disposal a very ready CO_2 indicator in the *type of the patient's respiration.* When this becomes deep and urgent, as if the patient had been running upstairs, it is quite certain that he is getting too much CO_2, and needs, as it were, a change of atmosphere.

The work of Yandell Henderson, Starling, and J. S. Haldane, to name only the most eminent among many workers in this field, has now brought home to us that the human (or animal) subject may suffer harm not only from *excess*, but also from *undue diminution* of CO_2. This gas is the normal stimulant of the respiratory centre, and if even a moderate reduction of the percentage normally present in the blood be effected, the centre ceases to function and the respiratory act is no longer performed. The circulation also suffers at the same time. The student may easily convince himself of the truth of these statements by voluntarily breathing as rapidly and deeply as possible. After some thirty to forty seconds of this exercise, he will become conscious of a strong wish to desist; but if he be a resolute person, and so manage to carry on until the end of the full minute, he will feel very giddy and uncomfortable, and will experience a period of some sixty seconds' 'apnœa,'

during which he will not breathe at all. Carrying this experiment further in the laboratory, Henderson has killed dogs simply by giving them artificial respiration to excess.

The question now arises, Does the condition of *CO_2 starvation* ever arise in anæsthesia? Probably in an ordinary short administration of nitrous oxide gas given 'on the valves'—*i.e.*, under such circumstances that the patient is not breathing the same volume of gas more than once—some slight diminution of CO_2 may possibly occur, but to so slight an extent as to be of little, if any, moment. But the case is probably far otherwise where nitrous oxide with oxygen is given for a prolonged period without ever permitting him to 'rebreathe.' Under such circumstances it is not uncommon to see some pallor and some faintness of the respiration, and these symptoms may fairly be ascribed to CO_2 deficiency, and should indicate the necessity for turning for a time to a rebreathing system which will permit some of the outgoing CO_2 to be conserved for the benefit of the patient.

From these very condensed remarks upon the action of the blood gases the student will appreciate that, in considering what effect he has produced by the action of nitrous oxide gas, he must ever bear in mind what increases or de-

creases he is at the same time effecting in the oxygen and carbon dioxide content of the blood and tissues. If he is giving nitrous oxide with little or no admixture of oxygen, he must bear in mind that anoxæmia must ultimately ensue. Again, even if anoxæmia has been prevented by a sufficiency of oxygen, he must remember that too prolonged 'rebreathing' may cause in his patient an excess of CO_2, while too prolonged breathing 'upon the valves' may cause the opposite condition.

When we turn to the remainder of our subject —namely, the true physiological action of nitrous oxide gas *per se*—we find there is singularly little to say.

We may summarize the present-day belief as to the action of nitrous oxide as follows:

1. Nitrous oxide enters into loose combination with the hæmoglobin of the red blood-corpuscles, and probably is so conveyed to the cells of the nerve centres.

2. It exerts a specific action on the central nervous system, which can be observed even when the addition of oxygen gas prevents the occurrence of anoxæmia.

3. Nitrous oxide is not a cardiac depressant. Given a heart muscle in average good condition, no sudden failure of its contraction need be

feared merely from the action of the gas itself. It is only if oxygen starvation be carried to excess that trouble arises, but, of course, a heart muscle which is quite starved of the necessary oxygen, and which is at the same time expected to pump blood through arteries in violent contraction from the same cause, will ultimately succumb, and will do so very rapidly if previously weakened by organic disease.

Apparatus required in the Administration of Nitrous Oxide.

1. The cylinders for storing the gas.
2. The apparatus used for allowing the liquefied gas to expand and to convey it to the patient's respiratory passages.
3. Mouth-openers (Mason's gag), props, etc.

Nitrous oxide, immediately after being prepared and purified, is liquefied under very great pressure, and stored, as before mentioned, in very strong steel bottles or cylinders of various sizes. Those most commonly in use are the 25, 50, and 100 gallon sizes, weighing from 3 pounds 7 ounces to about 8 pounds 7 ounces respectively.

There are two patterns of cylinder:

The Angle Pattern.
The Ordinary Pattern.

The first named are now largely used, as they are more convenient for general purposes.

The figures below illustrate the two bottles.

At B or B′ is a very powerful valve with the end squared so as to fit the pedal A or A′, by

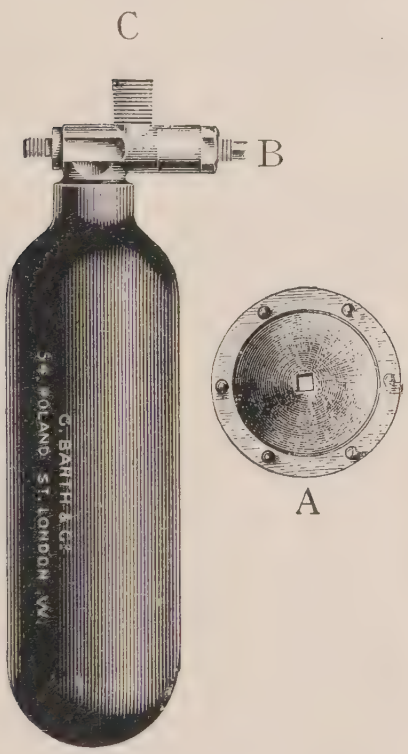


FIG. 8.—ANGLE PATTERN CYLINDER.*

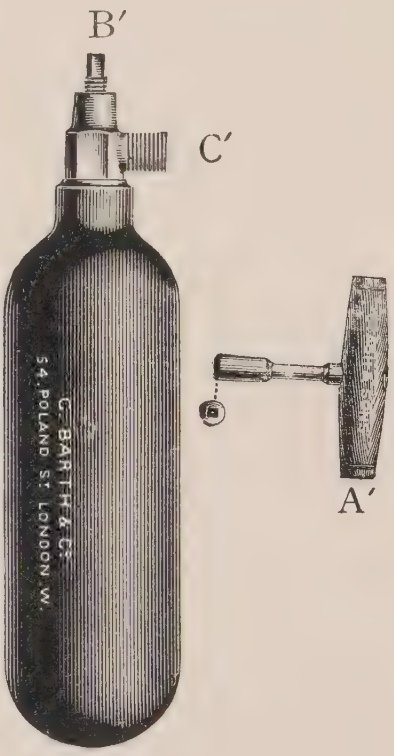


FIG. 9.—ORDINARY PATTERN CYLINDER.

means of which the gas is turned on and escapes at the orifice C or C′ into a tube attached for conducting it into the gas-bag or gasometer.

* Messrs. Barth's cylinders are fitted with a special arrangement to prevent moisture reaching the spindle (B) and causing corrosion and leakage.

Formerly the bottles were made of iron, but they are now made of steel, as when so constructed they can be made equally strong with much less metal.

There are a few practical points worth mentioning as regards storing of gas. When the bottles arrive, they should be at once weighed to check the weights noted on the label fixed on the bottle by the maker.

They should be then stored in a box or cupboard, where the temperature is fairly equable, not near a stove or fire, and not in a place where they are likely to be knocked about or to fall.

If, when a bottle is being used for the first time, the gas escapes in a slow and somewhat spasmodic manner, the bottle is probably *overfilled*, and frozen particles of liquid gas have escaped into the narrow exit and choked it. One may be mistaken and imagine the bottle empty, and if it be put aside *turned on*, a somewhat alarming explosion will suddenly occur. The bottle should be taken off the stand, and kept slightly turned on while *warm* water is trickled *slowly over the neck* until the gas comes fizzing out.

If a considerable quantity of gas is used at a time, the bottle usually gets coated with hoar-frost and then caution is needed in handling it to

avoid a severe burn. It is convenient to have two angle bottles coupled on to a stand, and to use the same one until empty, so that if it becomes empty during an administration the other is always ready and may be turned on, while the empty one is replaced at a convenient opportunity. A useful hint is to keep at hand three metal or ivory tags which can be attached by tape to the necks of the cylinders, and which are inscribed respectively 'Full,' 'In use,' and 'Empty.' Many years ago the author made several such sets of aluminium from the penny-in-the-slot automatic machines to be found on railway stations, using white metal for 'Full,' and red for the other two. He believes that he never spent a few coppers to better advantage, since conscientious attention to the correct use of the little signals makes mistake impossible.

Some bottles are very stiff in starting, and it is advisable to slightly loosen the valve with a wrench before commencing.

The foot-keys are made both in brass lacquered and nickel-plated steel, the latter being rather neater and less expensive.

In using them, the sole or heel of the boot, of the left leg usually, is firmly placed on the foot-key, and by rotating the leg to the left and outwards the valve is opened, and *vice versa*. With a little

practice the amount of gas escaping can be very nicely regulated.

Millauro described at the Anæsthetic Section of the Royal Society of Medicine an improved type of foot-key, much wider than those ordinarily sold, and which depended for a grip on the foot, not upon spikes, but upon a rubber facing. Certainly the usual type of foot-key is rather destructive to foot-wear, but this nuisance is mitigated if one loosens the valve first with a hand-key, and does only the finer work with the foot.

After the administration is over, great care is needed to see the valve is very tightly screwed down, otherwise a very slight escape may go on, and on the next occasion the gas-bottle may be found completely emptied.

It is essential that nitrous oxide be fixed in some substantial frame. If desired for foot use, a very usual arrangement is that shown in Fig. 10, where two *ordinary* cylinders of 100-gallon capacity are fixed together in a frame in such a way that the cylinders lie horizontally. The valve of the cylinder to be used is first opened by a hand-key, but the gas does not escape until the foot-key on the frame is also opened. Since the union between the cylinder and frame is rarely absolutely gas-tight, it is well to turn the

gas off at the cylinder as soon as the case is completed.

If the angle type of cylinder is used, the frame shown in Fig. 11 is very convenient.

Fig. 34 shows a frame by Coxeter and Son in which the cylinders lie obliquely. The same illustration shows the automatic gas regulator

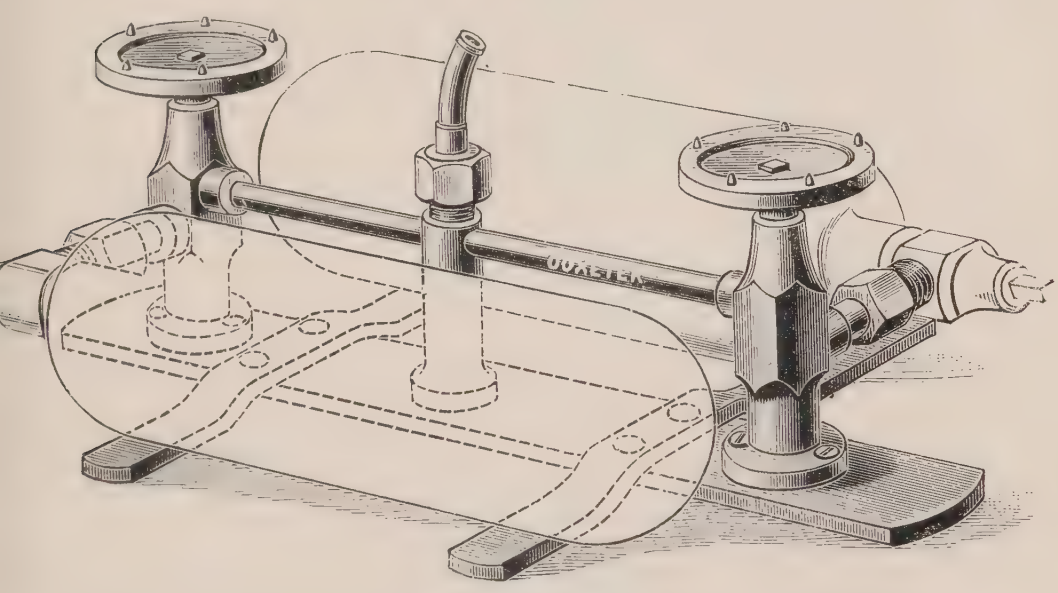


FIG. 10.—TWIN ORDINARY CYLINDERS ON FOOT FRAME.

designed by the same firm. This is a sort of box fixed either directly to the outlet from the cylinder or, as in the illustration, to the frame. Within the box is a diaphragm held down by a strong spring. The valve at the cylinder head is opened up in excess of the degree necessary to supply the requisite flow of gas, and the tension of the spring holding down the diaphragm dams

back the flow and gives a more even supply than can be secured direct out of the cylinder head itself.

To conduct the gas from the cylinder to the

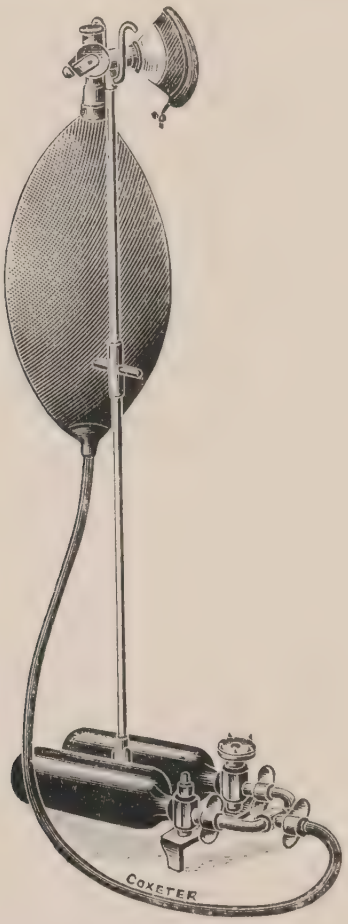


FIG. 11.—NITROUS OXIDE APPARATUS COMPLETE, WITH TWIN CYLINDERS ON FOOT STAND, TUBE, BAG VALVES, AND FACE-PIECE.

patient, the following parts are necessary in the apparatus:

1. Connecting the gas-bottles with the rubber tubing of the apparatus for administration is a

metal union consisting of a tapering nozzle and a screw-nut for fixing it. Between the two a leather washer is placed so as to make the union absolutely hermetic.

2. The rubber tubing between this and the bag is about $\frac{1}{2}$ inch in diameter, stoutly made, and about 4 feet long.

3. The bag to which this is attached is an impervious rubber bag, made of high quality rubber, and not too thick the capacity being about 3 gallons.

The best method of attachment is a simple vulcanite tap, so that, if it is desired to detach the bag from the tubing, this may be done, and, by turning the tap, any escape of gas is prevented.

4. To the upper end of the bag, and connecting it with the face-piece, is fixed the three-way stop-cock. This may be designed in either of two ways.

Fig. 12 shows the ordinary and well-known Barth three-way tap and face-piece; the indicator on the tap has three possible positions designated on the dial as 'Air,' 'Valves,' and 'No valves.' If the indicator is pointed backwards towards the bag at the position marked 'Air,' the end of the bag is closed, and the patient would breathe air only. With the indicator in the middle position

of 'Valves,' the inspiration of the patient will draw gas from the bag through the inspiratory

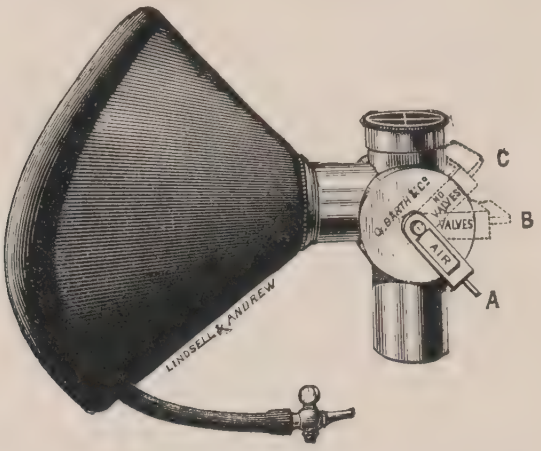


FIG. 12.—BARTH'S THREE-WAY STOP-COCK AND FACE-PIECE.

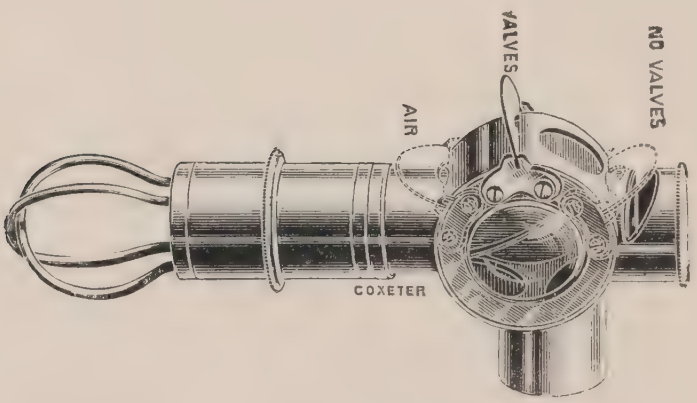


FIG. 13.—THREE-WAY STOP-COCK WITH GLASS SIDES, THROUGH WHICH THE INNER DRUM WITH THE VALVES CAN BE SEEN. (Coxeter and Son.)

valve now in operation, but the expiration will close this valve and open the expiratory valve

to be found at the distal end of the three-way tap, and escape into the general atmosphere of the room. In the third position, called 'No valves,' rebreathing takes place; the patient will draw his inspirations from the contents of the

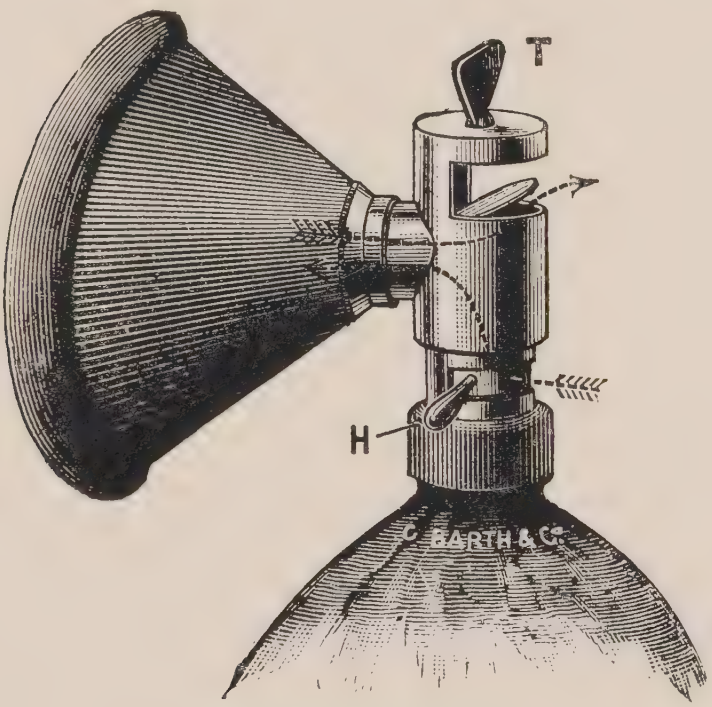


FIG. 14.—HEWITT'S WIDE-BORE GAS VALVES

bag and return his expirations to the same location.

Fig. 14 shows the Hewitt type of inhaler. The calibre of the orifices through which respiration takes place is greater than that in the Barth three-way tap—at any rate, as ordinarily supplied.

Although differently designed, the same possibilities of 'air,' 'valves,' and 'no valves' are present in the tap of the Hewitt instrument.

5. *Face-pieces :*

(1) Leather and rubber sheeting.
(2) Compo and pad.
(3) Compo and glycerine.
(4) Celluloid and metal.

Whether the anæsthetic be gas, ethyl chloride, or ether, it is equally important to secure a good face-piece which does not allow of leakage.

To prevent this entirely may be a very difficult matter if the patient wears a large moustache or a beard, but with an ordinary clean-shaven face a properly constructed face-piece makes it quite easy.

The face-piece, despite the less degree of asepsis, should be in one piece. For those of metal or celluloid with a movable rubber pad we have no preference, but quite the contrary, as leakage is more likely to occur, and they are—the celluloid type, at any rate—more fragile and uncertain.

In our experience the best type of face-piece is one made of a solid basis of rubber and leather compo with the inflatable pad fixed up with some adhesive substance.

This is very strong and lasts a long time; and

while it cannot be boiled, it can be well soaked in antiseptic solution.

Next to that comes the type with the inner layer

FIG. 15.—GUY'S ARRANGEMENT FOR NITROUS OXIDE.

of leather covered on each side with a layer of thin sheet-rubber.

The shape is important. The opening which

fits over the patient's face should be an oblong with the greater breadth at the lower end. It should be neither round nor angular at the sides, as one sometimes finds in foreign and cheap types.

If the apparatus is not being used fairly regularly, the indiarubber valves are apt to dry and curl up at the edges. This can be avoided by moistening them occasionally with a little warm water or weak carbolic lotion. Another useful method is to dry carefully after use, and then to apply powdered talc, being careful to blow away excess of the powder before beginning another administration.

The Preparation of the Patient for Nitrous Oxide.

Little or no previous preparation in the way of fasting is necessary, but the gas should not be inhaled soon after a full meal. In all cases it is well to allow two hours to elapse between a meal and the administration. Prolonged fasting is, however, undesirable, and, indeed, increases any liability to fainting.

In spite of the extreme safety of nitrous oxide, it is distinctly desirable for the administrator to 'take stock' of the patient before undertaking the production of anæsthesia.

If the patient looks fit and robust, the dentist may merely remark that he assumes he has good health. If the patient is pale, anæmicor 'seedy' looking, he may go a little further, and inquire as to any fainting fits, etc. *If there seems any doubt whatever as to the physical fitness of the patient, the ordinary medical attendant should be undoubtedly communicated with,* and certainly if such a wish is expressed, or it seems in any way desirable, his presence at the proposed administration secured. This will take much responsibility off the shoulders of the dentist in any case, and if anything untoward does happen, the medical man may afford valuable assistance.

In most medical schools students are now being taught to give gas along with other anæsthetics, so that the practitioner himself may be able to undertake the production of anæsthesia.

It is well, as before mentioned, especially when dealing with young children, to get the bladder emptied before putting them in the chair, and corsets should be removed or unlaced. The upper buttons of a coat or dress should be undone, and collar or brooch removed. Gloves, spectacles, hat, and artificial teeth are also to be removed.

Patients' friends are usually better out of the operating-room, but if they or the patient expressly desire it, they must be allowed to remain,

and should be placed in such a position as not to be able to see the patient's face, which, when he or she is fully under the influence of gas, may be far from pleasing in appearance. In connection with the subject, it is well again to state that under no circumstances should gas or other anæsthetic be administered to a female without the presence of a third party, preferably one of her own sex, as charges of criminal assault, usually made in all good faith, are not uncommon (see p. 32).

The patient is now seated in the chair, and must be placed so as to suit both the requirements of the anæsthesia and the operation. He should be made to sit well back in the chair, the legs uncrossed and not too much flexed, nor pressed firmly against the foot-rest. This last is of special importance when the patient is tall, as opisthotonos, or arching of the back, will often occur when he becomes unconscious, so that he should be told to place his feet on the floor *beside* the foot-rest.

The head-rest must be brought well forward and fixed firmly in such a position that the long axis of the patient's head is in continuation with the long axis of the body.

The importance of loose clothing during anæsthesia—whether induced by gas, gas and oxygen, or ether—is very great, in order to prevent any

possible constriction of the upper respiratory passages, and to allow complete expansion of the lungs by diaphragmatic action.

If there are tightly-laced corsets or waistbands full descent of the diaphragm is interfered with, abdominal breaths cannot be taken, and the rapid exchange of the air in the lungs for the anæsthetic gas cannot be effected. If the operator particularly wishes the head somewhat thrown back, this should be effected after the anæsthesia has been established.

Before starting, the patient is asked to clasp his hands, or to firmly grip the arm of the chair (*not* of the operator !), and this is of especial value when dealing with nervous people.

Bellamy Gardner uses a belt or strap to hold the patient up in the chair.

The Effects produced by the Inhalation of Nitrous Oxide.

It is customary to divide the process of inducing and establishing anæsthesia into three stages:

First Stage.—The gas being turned on, the patient is at once conscious of the sweetish but not unpleasant taste which it possesses.

A feeling of warmth on the lips and an indescribable though not unpleasant numbness in the limbs is noted, while the patient has an irre-

sistible desire to breathe more quickly and deeply. He then experiences a curious feeling of expansion and ' thrilling ' throughout the body. Ringing in the ears is common.

Consciousness is lost, however, in twenty to thirty seconds, almost before the patient has time to define his sensations, and the respirations deepen and become more regular.

The pulse is fuller, firmer, and somewhat quickened. The power of hearing persists during this stage, and, indeed, may become hyperacute, so that silence is very desirable.

Second Stage.—The patient is now unconscious, but not fully anæsthetized. Movement of the arms and legs is common, and this may be of an almost methodical nature—*e.g.*, beating rhythmically on the floor with the feet, or moving the arms as in rowing. These movements are known as ' occupation spasms.' Excitement is not usual if the gas be properly administered and air duly excluded. Vivid dreams are common, and may be rendered extremely unpleasant by commencing any operative procedure at this stage. Further, if an extraction be attempted, shouting and excitement will almost invariably occur.

Respiration is deeper and quicker than normal, and is regular in character. The pulse is full and more rapid than usual; the conjunctival reflex is

still present. The pupils are gradually dilating, and the complexion is growing dusky, the change being especially marked in people of fair complexion. The eyelids often twitch and become slightly separated.

Third Stage.—The respiration now loses its regular character, and a curious and characteristic 'snorting' sound or stertor becomes noticeable. This is owing to some obstruction in the air-way, due to spasmodic contraction of the elevators of the larynx raising it towards the epiglottis and base of the tongue. This stertor will be always more marked if the patient's head is at all extended, from the head-rest of the chair being too far back.

The muscles may be quite relaxed, and the arms fall limply if raised by the anæsthetist, but some rigidity due to clonic or tonic spasm is more common if the gas is at all pushed. The spasmodic contractions are first noticed in the fingers, but they spread through the whole body, and may be so violent as to jerk the patient out of the chair. These movements are commonly known as *jactitation;* they are undoubtedly anoxæmic in origin, and represent the convulsions of asphyxia as modified by the anæsthetized condition of the motor centres.

The facial muscles are in some cases more

affected than any, and the appearance of the patient is then usually extremely unpleasant. Sometimes the *erector spinæ* muscles are chiefly affected, and then the phenomenon *opisthotonos* is seen, the patient's back forming a complete arch, while he is merely supported by his heels on the foot-board and his head on the head-rest. This very awkward development usually disappears on lightening the anæsthesia by giving air or oxygen.

Micturition and the passage of flatus, or even fæces, may occur in this stage, particularly in children, unless the precaution already mentioned of insisting upon the patient emptying the bladder has been taken.

The pupil is now usually well dilated, conjunctival reflex gone, but this is not always the case.

The facial expression is usually considerably distorted, the eyeballs rotate in an unpleasant manner, and fat people of the apoplectic type become markedly cyanosed.

The Administration.

Before adjusting the face-piece, it is necessary in the large majority of cases to insert a mouth-prop (such as described previously). Care must be taken that it lies quite straight and firmly in the bite. The usual practice is not to place it further forward than the bicuspid teeth, for fear

that masseteric spasm set up during anæsthesia might be so great as to force the incisors or canines out. Guy, however, habitually places it between the incisors, and designed his props therefore with parallel cusps (see Fig. 7).

In some cases where there is an alveolar abscess it may be quite impossible to open the mouth sufficiently to insert a prop. In such cases the administration may be gone on with, and, when the patient is under, the mouth may be opened by means of a wooden wedge or Heister's screw-gag.

The face-piece having been adjusted with the pointer of the stop-cock turned to 'Air,' the patient is instructed to breathe quietly to and fro (not to take deep breaths), and the pointer turned to 'Valves.' The gas is now breathed in from the bag through the inspiratory valve into the mouth and lungs of the patient, and expired, mixed with CO_2, etc., through the expiratory valve.

This may be continued for eight or ten breaths, when the pointer may be turned right on to 'No valves,' and to and from breathing be permitted until anæsthesia is induced. The bag should not be allowed to become distended, but just moderately full, so that the gas is administered rather above the atmospheric pressure.

Care must be taken throughout to avoid any

leakage around the face-piece, which is particularly apt to occur around the upper part.

It may be necessary in some cases to exercise a little pressure here by means of the forefinger and thumb of the left hand.

Recovery from the Anæsthetic.

From the moment of the removal of the face-piece the degree of narcosis lightens, and anæsthesia passes into analgesia with excitement. The pulse, which has been increased in rapidity and tension, returns to its almost normal rhythm with the first good inspiration, lips and skin regain their normal hue, stertor and jactitation disappear, and the respirations become quick and shallow or panting.

The conjunctivæ lose their congested appearance and regain their tactile reflex. The patient feels somewhat dazed, as when awaking from a deep sleep, but rapidly regains complete consciousness, and complains of no ill-effects.

As soon as the extraction is complete, the head and shoulders of the patient should be drawn well forward, and blood so prevented from getting into the larynx and causing cough and irritation. If the patient is somewhat slow in coming round, provided colour and breathing are good, no vigorous efforts should be made to awake him;

and if a prop has been inserted into the mouth, it should be left alone until the patient is quite conscious, otherwise the forcible removal of it will give him a strong impression, most difficult to eliminate, that it was the removal of the tooth that he felt.

When the mouth has been thoroughly washed out and the hæmorrhage has stopped, the patient may be allowed to sit back in the chair a few minutes before rising, as the power of locomotion is at first somewhat impaired. He or she may then be allowed to go to another room for a further ten minutes' rest, or at once to a cab, without any fear of ill-effect.

Time taken to induce Anæsthesia—Duration of Anæsthesia.

There seems to be a considerable discrepancy of opinion on these points. Sir Frederick Hewitt found the average time occupied in producing full anæsthesia is 55·9 seconds when dealing with a fairly robust, fully-developed adult. Silk gives it as 67·5 seconds, and the committee of the Odontological Society 73 seconds. Hewitt found the usual available anæsthesia to be 30·3 seconds, while the Odontological Society found it to average 24·7 seconds only.

Children and feeble anæmic subjects become

rapidly cyanosed and stertorous with nitrous oxide often in about 20 seconds but the length of the anæsthesia is usually correspondingly short.

It is, of course, very difficult to decide when the true anæsthesia terminates. The period of anæsthesia, however, depends to a considerable extent on the duration of the inhalation, a long inhalation usually affording a long anæsthesia, and *vice versa*.

Further, the available anæsthesia may be prolonged for some seconds by allowing a breath of air at every fifth respiration during the induction of anæsthesia. This fact was pointed out by the late G. Rowell; he usually commenced allowing air after the patient had had about fifteen breaths of pure gas.

After-Effects of Nitrous Oxide.

The after-effects of nitrous oxide are usually exceedingly slight and transient; indeed, there is no known anæsthetic which produces less constitutional disturbance.

Slight headache and vertigo, accompanied by a feeling of lassitude and depression, are occasionally seen. If at all marked, some impurity in the gas may be suspected, or the administration may have been faultily conducted, and too much CO_2 inhaled along with the nitrous oxide from

excessive rebreathing; or some blood may have been swallowed.

If the patient has had a meal within the last two hours, these symptoms are more prone to occur, and may be accompanied by nausea and even active vomiting. Accordingly, it is well before administering to inquire when the last meal was taken. Pallor and faintness are due usually to stomachic disturbance and threatened vomiting rather than to any direct circulatory disturbance.

Two administrations at a sitting can rarely be carried out without causing a good deal of after-discomfort and headache, and should therefore not be undertaken unless the patient lives at a distance and it is especially desirable to complete the extraction.

Continuous Administration of Nitrous Oxide.

During the last ten or fifteen years many attempts have been made to administer nitrous oxide in a more or less continuous manner, so as to produce and maintain an anæsthesia suitable for prolonged dental extraction, and even for surgical operations.

So far as surgery, particularly major surgery, is concerned, nitrous oxide gas can only be suitably administered when mixed with pure oxygen; any attempt to maintain a safe degree of aeration

over a prolonged period by diluting the nitrous oxide with atmospheric air only is likely to give such imperfect results that no self-respecting anæsthetist would care to suggest it as suitable for anything more elaborate than the opening of an abscess or the removal of a piece of metal, as was, of course, widely done during the Great War. But the type of anæsthesia obtainable from nitrous oxide diluted by air may be quite adequate for dental work, it being, of course, understood that the administration must necessarily be *per nasem*, so as to leave the mouth free for the attention of the dental operator.

Nasal Administration of N_2O.

Some of the methods employed to obtain a prolonged anæsthesia only require a very brief notice. Coxon used a metal tube to convey the gas into the mouth, and, having produced anæsthesia in this way, he maintained it during the extraction by keeping up a continuous stream of gas.

Harvey Hilliard first induced anæsthesia by the ordinary face-piece, and then kept up the supply of gas through a nasal tube. This method is not to be recommended, for it is apt to cause considerable epistaxis. Further, if there be any adenoid growths or nasal obstruction, it cannot be used.

Coleman in 1899 brought out yet another apparatus, which consisted of a nose-piece attached to the gas-bag by a tube, and when in use fixed by a kind of clamp arrangement to the patient's head.

This apparatus was the basis on which later improvements by H. J. Paterson and others produced a thoroughly reliable and useful means of keeping up continuous gas anæsthesia. For supplying the gas Paterson used the ordinary two-bottle gas-stand with nozzle attachment. To this is adapted a $\frac{1}{2}$-inch rubber tube, which enters a small 2-gallon rubber bag to which is fixed a two-way stop-cock. From the stop-cock pass two narrow, very flexible rubber tubes, which pass to supply a metal nose-piece fitted with rubber air-pad to admit of very accurate adaptation to the patient's nose and face. Having filled the bag about two-thirds full of gas, a mouth-prop is inserted, the nose-piece carefully adjusted, and the stop-cock turned on. A stream of gas now passes into the nasal passages during each inhalation. The patient is instructed to inspire through the nose and expire through the mouth, which he usually can do quite well. In a perceptible proportion of cases, however, some artificial aid to this form of respiration is required, and a celluloid mouthpiece is provided, with an

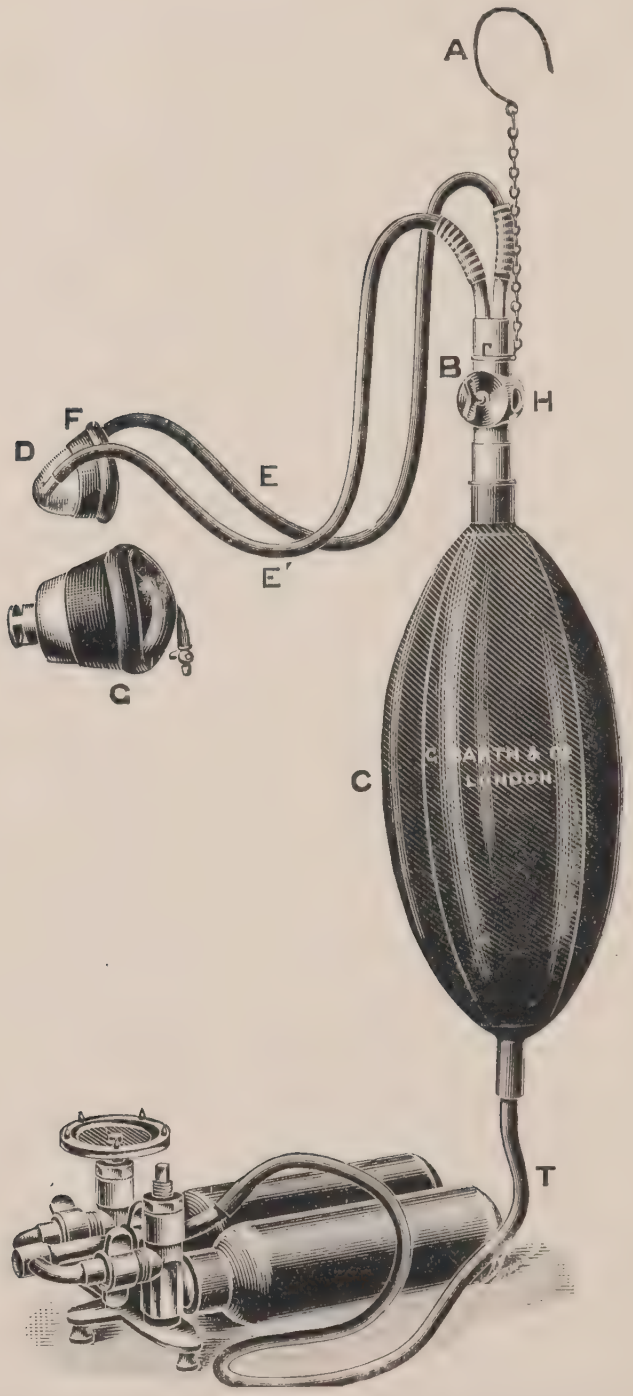


FIG. 16.—PATERSON'S APPARATUS FOR NASAL GAS.

expiratory valve only; this is carefully adapted to the mouth to prevent any air entering, while still allowing the patient to expire. In 75 per cent. of cases anæsthesia may be completely established in forty to fifty seconds without any use of the mouthpiece. If this is used, however, less time will be needed. The patient becomes only slightly dusky, and any stertor or cyanosis is readily removed by stopping the supply of gas, and turning the tap of the two-way stop-cock so as to lie horizontally. In good types of patients who are not nervous or alcoholic it is quite possible to keep up a safe anæsthesia almost indefinitely—at any rate, for ten to fifteen minutes —long enough for a moderately dexterous operator to ' clear a mouth.'

It is often necessary to keep a good deal of pressure on the gas-supply, with the bag distended, to keep the patient well anæsthetized. For ten minutes' anæsthesia 30 to 40 gallons of gas will be necessary.

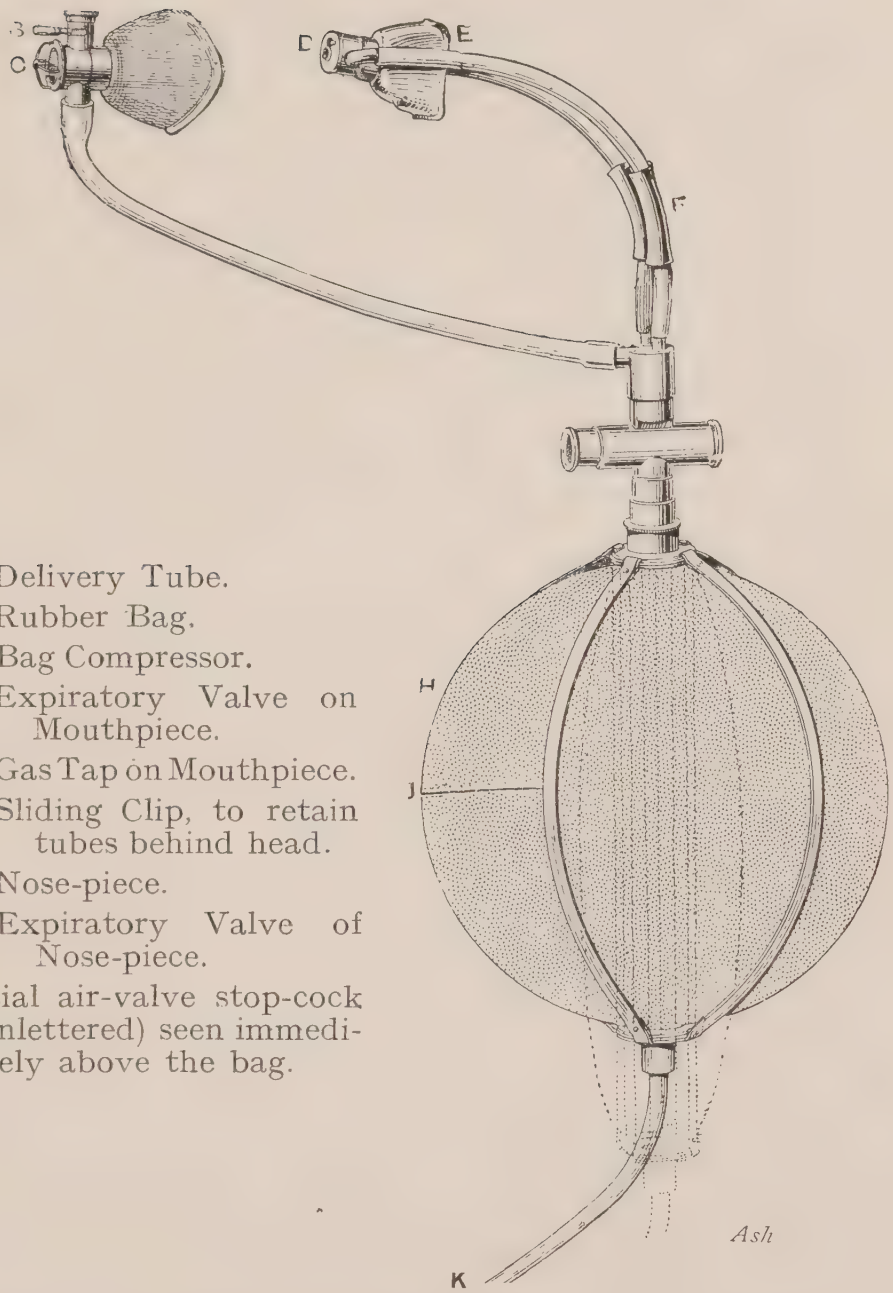
On recovery from the anæsthesia patients are usually very fresh indeed, any disagreeable after-effects being usually due to swallowed blood.

As already mentioned, the patient is during the conscious stage instructed as far as possible to inspire through the nose and expire through the mouth, but when anæsthesia has been fully

established, it is usual for him to revert to breathing both up and down the nose. This can, of course, be largely prevented by exercising considerable positive pressure, but a prolonged period of such pressure is not beneficial, and is also very wasteful of gas. Later workers have therefore provided an expiratory valve in the nose-piece which permits to-and-fro breathing up and down to the nose without permitting the expirations to travel along the pipes which deliver the gases. Of inhalers with this improvement, the best known is the following:

The Coleman No. 4 Aseptic Nasal Inhaler.

Fig. 17 shows this apparatus as made by Messrs. Claudius Ash, Son, and Co., Ltd., which is a great advance on anything previously offered for the nasal administration of nitrous oxide and air. The nose-piece is well designed and easily cleansed; it is provided with a most efficient expiratory valve. The stop-cock is so designed as to permit of the admission of definite mixtures of gas and air to the inhaler. Moreover, even if gas is being delivered from the bag at some considerable pressure, as may be necessary in order that inhalation of too much air by the mouth may be prevented, a certain amount of air will still enter the air-hole of the stop-cock,



K—Delivery Tube.
H—Rubber Bag.
J—Bag Compressor.
C—Expiratory Valve on Mouthpiece.
B—Gas Tap on Mouthpiece.
F—Sliding Clip, to retain tubes behind head.
E—Nose-piece.
D—Expiratory Valve of Nose-piece.
Special air-valve stop-cock (unlettered) seen immediately above the bag.

FIG. 17.—COLEMAN'S ASEPTIC NASAL INHALER (ASH'S NO. 4).

thus guarding the patient from the incidence of undue anoxæmia. Lastly, the fitment of a mouth inhaler provides a stand-by to meet the exceptional case of a patient who cannot be induced to inspire properly through the mouth.

Mr. Coleman gives the following details of this apparatus and its use:

'This nasal inhaler consists of a nose-piece (see illustration) with expiratory valve, two conveying tubes, a sliding clamp, a two-way stop-cock, the remaining parts being those of an ordinary gas apparatus with the addition of a combined mouth cover and inhaler and a gas-bag compressor.

'*Nose-Piece.*—The nose-piece, which is carefully adapted to the shape of the nose, is fitted with two lateral tubes, which open into a chamber under the nostrils, and thus convey the gas directly to the nose. The snug fit of the nose-piece and the position of the openings render an india-rubber pad unnecessary.

'*Conveying Tubes.*—The two conveying tubes on the nose-piece are connected with the stop-cock by means of flexible tubes, and the nose-piece is held in position when the tubes are adjusted on the head by the sliding clamp, the clamp being kept where it is set by the weight of the gas-bag and the flexible tubes. The conveying tubes on each side of the nose-piece are

arranged so that the flexible tubes exert their force in bringing the nose-piece evenly and firmly over the patient's nose.

'*Stop-Cock.*—The stop-cock consists of an outer and an inner drum. The inner drum, which is graduated and open at one end, can be projected beyond either end of the outer drum, and according to the position in which it is set, gas, air, or a mixture of the two is delivered to the inhaler. The movement of the inner drum controls the size of the apertures which admit air and gas; both apertures are similar in shape and protected by a common inspiratory valve, which prevents rebreathing into the gas-bag and allows of a definite mixture of air and gas being admitted to the inhaler.

'*Combined Mouth Cover and Inhaler.*—The mouth cover is made entirely of metal. It has been carefully adapted to the shape which the mouth assumes when partly open—as, for instance, with a mouth-prop *in situ*—and is made in two sizes. It serves as an inhaler when pressure is applied to the lever which opens a channel to the gas-bag. On the lever being released the gas-bag is shut off, and the mouth inhaler becomes merely an expiratory chamber.

'*Gas-Bag Compressor.* — The gas-bag compressor ensures a constant flow of gas to the

inhaler, and prevents inhalation of air through the mouth during the operative period. The pressure of gas can be increased by distending the bag, which in turn distends the spring-tempered metal bands of the compressor.

'The apparatus here described comprises some valuable additional features which were not embodied in the original form of inhaler, as, *e.g.*, an expiratory valve on the nose-piece, the *special* valve-seat in the stop-cock, the bag compressor, and the mouth inhaler.

'The following reasons led to the introduction of these innovations:

'*The Expiratory Valve on the Nose-Piece.*—The mouth only acts as an efficient expiratory channel while consciousness remains; as soon as anæsthesia approaches, the soft palate and tongue lose their muscular tone, tend to fall together, and partly or completely shut off the buccal cavity from the cavity of the pharynx. Under such conditions, expiration takes place around the nose-piece, or back into the bag, or in any direction in which least resistance is encountered.

'A second reason for the employment of an expiratory valve on the nose-piece is the comfort of patients. Patients can expire more freely and comfortably when allowed to do so through

the nose as well as the mouth than when they are only permitted to expire through the mouth.

'Further, the employment of a *valved* nose-piece does away with the necessity of instructing patients how to breathe; they can use either channel for expiration with almost equal advantage to the anæsthetist.

'Briefly stated, the advantages of an expiratory valve are these: the comfort of patients during consciousness, and the liberty of free expiration during unconsciousness.

'*The Special Valve-Seat in the Stop-Cock.*—This innovation permits of definite quantities of air being admitted to the inhaler. The principle of employing a single inspiratory valve for controlling both the gas and air inlets to the stop-cock enables the anæsthetist to administer definite quantities of air with the nitrous oxide stream under any pressure of nitrous oxide. The nitrous oxide, in raising the common inspiratory valve, likewise permits of the entrance of air when the air aperture is set for this purpose.

'*The Gas-Bag Compressor.*—This consists of two metal rings, placed respectively above and below the gas-bag, to which the extremities of four narrow metal strips are fixed. These four metal strips embrace the gas-bag. The empty bag is passed through the rings, and the stop-

cock is adjusted to the neck of the bag in the usual way. As the bag is distended the metal strips spread out over its surface, and, owing to their springiness and their constant tendency to return to the vertical position, a steady and firm pressure is exerted on the bag and its contents.

'The bag compressor can be made for any size of bag, but a bag of 1½ gallons capacity forms a useful size and shape for the nasal administration of nitrous oxide gas.

'The bag should only be slightly distended when the administration is commenced, and it need not be distended beyond half its capacity during the induction period. As long as the anæsthesia remains satisfactory, the bag may be kept uniformly distended. As a rule it is advisable to have the bag slightly less than half filled while the operator is working on the lower jaw; fuller distension will only be necessary should the patient show signs of regaining consciousness. In such a case it may be necessary to shut off the expiratory valve on the nose-piece, in addition to increasing the distension of the bag.

'*The Mouth Inhaler*.—The means of converting the mouth cover into an inhaler has been introduced for use on those patients who do not breathe readily through the nose, either from perverseness or from partial inability to do so.

The induction of anæsthesia with the mouth inhaler is similar to that of the ordinary method of administration, except that separate inhalers are employed for the nose and the mouth, instead of one common inhaler.'

Advantages of the Nasal Method.

It is a quick and safe method of obtaining one to ten minutes' anæsthesia, but especially useful where only two or three minutes' anæsthesia are wanted for the removal of four temporary molars, two or three roots, or any procedure requiring rather more than the time obtained when gas is given by the ordinary way. The patients are able to leave the dentist's room almost immediately, nausea and vomiting being extremely rare.

As Bellamy Gardner points out, the great advantage of the nasal apparatus for systematic induction of N_2O anæsthesia is that we never need charge the patient up with the gas. We may divide full N_2O anæsthesia when there is stertor, lividity, and jactitation into, say, ten degrees. If we are giving the gas nasally we need only reach, say, the fifth degree when the patient is ready, and all we have to do is to keep him anæsthetized and maintain a good colour.

Details of 100 Cases of Anæsthesia produced by Continuous Administration of Nitrous Oxide.

Average anæsthesia, 2·84 minutes.
Average time for induction, 35 to 40 seconds.

No.	Sex.	Age.	Duration of Anæsthesia.	Extractions.	Remarks.
			Minutes.		
1	F.	14	5	12	Noisy. Thirty gallons gas used.
2	F.	54	1	7	Patient very feeble.
3	F.	26	4·5	5 stumps	Hypnotic condition afterwards.
4	M.	19	3	3 stumps	
5	F.	14	1	4 temp. molars	
6	F.	17	5	17 teeth	Very fresh afterwards.
7	F.	35	2·5	6 ,,	Opisthotonos.
8	F.	30	5	16 ,,	Excellent colour.
9	M.	28	4	4 stumps	Powerful man.
10	F.	28	4	2 ,,	Very good colour.
11	F.	23	1·5	8 teeth	
12	F.	10	3	4 temp. molars	Very refractory child; started with ordinary face-piece, and changed to Paterson after.
13	M.	22	3·5	3 stumps	Some cyanosis.
14	M.	9	3	3 ,,	
15	F.	35	2	2 ,,	Mitral stenosis; feeble patient.
16	F.	24	2	12 teeth	Screaming.
17	M.	20	1·5	1 very bad stump	
18	M.	9	3	2 stumps	
19	F.	35	3·25	4 ,,	
20	M.	12	4	4 temp. molars	
21	F.	32	3	16 teeth	
22	F.	27	2	2 stumps	
23	F.	12	2	1 very bad stump	
24	M.	45	2	3 teeth	Alcoholic; violent struggling and phonation. Broke arm off chair.
25	F.	20	2	3 ,,	
26	F.	30	2	1 root	

No.	Sex.	Age.	Duration of Anæsthesia.	Extractions.	Remarks.
			Minutes.		
27	M.	23	3	1 very bad root	
28	F.	25	1	1 very bad root	
29	F.	32	0·75	1 tooth	Seventh month of pregnancy; very delicate. No cyanosis or jactitation.
30	F.	45	3	8 teeth	
31	F.	34	1	2 ,,	
32	F.	30	5	13 ,,	
33	F.	30	4·5	12 stumps	
34	F.	27	1	1 stump	
35	M.	44	1·5	18 teeth	
36	F.	19	3	8 ,,	
37	F.	35	3·5	12 ,,	
38	M.	44	2·5	10 ,,	
3	F.	26	3	13 ,,	
40	M.	62	3·5	5 ,,	Very acute gum-boil upper lip. Nose-piece changed to large face-piece.
41	M.	10	2·5	4 temp. molars	
42	M.	18	3·5	10 teeth	
43	F.	26	3	10 ,,	
44	F.	35	2	4 ,,	
45	F.	32	1	2 ,,	Nervous. Opisthotonos. Shaky afterwards.
46	F.	32	1·5	5 roots	
47	M.	48	2	2 stiff molars	Opisthotonos and stertor.
48	F.	30	5	19	Phonation; very fresh after.
49	F.	32	3	3	Noisy. Opisthotonos.
50	M.	54	2	12	Very robust patient.
51	M.	18	8	16	
52	F.	28	10	18	
53	F.	19	4·5	12	Excellent colour.
54	M.	12	4	5	Two administrations; vomited; three hours since food.
55	F.	15	2·5	4 stumps	Very good colour.
56	F.	24	5	15 ,,	
57	F.	26	2·5	4 ,,	
58	F.	18	3·5	8 teeth	
59	F.	29	5·5	29 ,,	Very fresh after; walked home.

Details of 100 Cases of Anæsthesia (*contd.*).

No.	Sex.	Age.	Duration of Anæsthesia.	Extractions.	Remarks.
			Minutes.		
60	F.	34	1·5	12 teeth	
61	M.	23	7	29 ,,	
62	F.	27	6·5	25 ,,	
63	F.	21	2	4 roots	
64	M.	17	2	8 ,,	
65	F.	20	1·75	17 teeth	Patient very pleased.
66	F.	13	1·5	4 ,,	Temporary molars.
67	F.	30	2	8	
68	F.	33	3	4	One a very bad stump.
69	F.	29	3	7	
70	M.	28	2·5	9	
71	F.	23	2	3 roots	Deaf-mute.
72	F.	38	2·5	5 ,,	
73	F.	28	1·75	3	
74	F.	50	1	1 root	
75	F.	13	1·3	4	
76	M.	21	2	4	
77	F.	35	3	(Antrum case)	Patient very cyanosed. High colour.
78	F.	13	1·5	4	Temporary molars.
79	F.	38	3	1	Very bad stump.
80	M.	12	1·25	4	Temporary molars. Loud phonation; awoke smiling.
81	F.	22	5	9 teeth	Three pulps were also drilled out.
82	F.	27	1·5	2 roots	
83	M.	35	3	1 root	A very stiff root.
84	M.	20	3·5	9 roots	
85	F.	30	1·25	3 ,,	
86	M.	35	1	5 teeth	Marked opisthotonos; stopped administration.
87	M.	38	9	12 ,,	Forty gallons N_2O used.
88	F.	28	3	10 ,,	Opisthotonos.
89	M.	30	1·5	3 roots	
90	M.	24	1·5	1 root	
91	F.	66	1·25	4 teeth	
92	F.	35	1	1 root	
93	F.	45	1·5	5 teeth	
94	F.	40	1	4 ,,	
95	F.	28	8	18 ,,	
96	F.	30	3·5	5 roots	
97	M.	28	4	7 teeth	Noisy.
98	F.	48	2·5	8 ,,	
99	F.	39	2	3 ,,	
100	M.	24	2	3 ,,	Opisthotonos.

Disadvantages.

Unless the dentist has a capable assistant who can either act as anæsthetist or operator, the apparatus cannot be used without outside assistance. Considerable skill and practice are needed to use the apparatus efficiently, while the risk of overdose from nitrous oxide, if air be not duly supplied from time to time, is of course increased.

Excitable persons, alcoholics, and young children are not good subjects for nasal gas unmixed with oxygen gas.

The table, drawn from an earlier edition of this book, shows the results which could be attained even by the original Paterson apparatus in the hands of so skilled a man as the late Dr. Luke.

CHAPTER IV

ETHYL CHLORIDE (C_2H_5Cl)

Ethyl chloride, first employed by Heyfelder, is a colourless, highly volatile liquid of aromatic odour and sweetish taste and neutral reaction. It volatilizes at all ordinary temperatures without leaving any residue, but if at all decomposed gives off a slightly garlicky odour from the skin when evaporated on the palm of the hand. It has a density of 0·92 at 0° C., and the density of the vapour, taking air at unity, is 2·3. It boils at 12·5° C.

It is very readily soluble in alcohol, but sparingly so in ether. The drug is very combustible, burning with a green flame and setting free hydrochloric acid. It is manufactured by subjecting a boiling solution of chloride of zinc (in alcohol) to the action of hydrochloric acid. When put up in cylinders holding from 50 to 60 c.c., it shows no tendency to decompose or undergo chemical change even when exposed to light. Its purchase in larger bulk than this is not to be advised, except

to those who are skilled chemists and accustomed to handling very volatile substances. Ethyl chloride has a solvent action on various substances, but no appreciative action on rubber sheeting, any more than sulphuric ether. It will, however, rapidly destroy vulcanite stop-cocks.

In spite of its extreme volatility, if a few c.c. be decanted into a small test-tube of thick glass no considerable amount of the drug will be lost, even if the tube be exposed for from five to ten minutes in a room at 70° F. The explanation, of course, is found in the fact that the evaporation of the first moiety exercises a marked cooling action upon the remainder. But the tendency to ebullition is very marked if a small particle of glass or metal be dropped into the tube.

Apparatus for administering Ethyl Chloride.

While various methods have been suggested for administering the drug, and patients have been and can be anæsthetized by open methods, one has no hesitation in saying that the most satisfactory method is the closed method with some type of bag inhaler. It should be simple in design and have a wide bore.

The open method of administering this drug is quite a feasible proposition if it be sprayed fairly lavishly upon a mask covered with gauze,

and fitted to the face so accurately that the patient breathes *through* the gauze; but in strong adults the anæsthesia obtained is light in type unless very large quantities are used, and the method has therefore not much scope in dental work, and will not need description.

As regards closed inhalers, the essential parts are—

(1) A good face-piece with a pneumatic pad.

(2) A rubber bag of 1-gallon capacity.

(3) A metal angle junction tube with an aperture at one aspect, or another through which the ethyl chloride may be introduced.

(4) A glass vial marked in c.c. into which the chosen dose of ethyl chloride may be measured.

(5) A rubber tube to connect the vial either with the metal angle junction, or with the distal end of the rubber bag. Of these two methods of connection the former is to be preferred, since a plain bag with no tube connection at its base is more readily purchased when replacement is necessary.

Daniell's Inhaler.

The above simple requirements are all fulfilled by the inhaler designed in 1906 by Dr. Bamffylde Daniell, then of Edinburgh, now of Cape Town, and shown in Fig. 18.

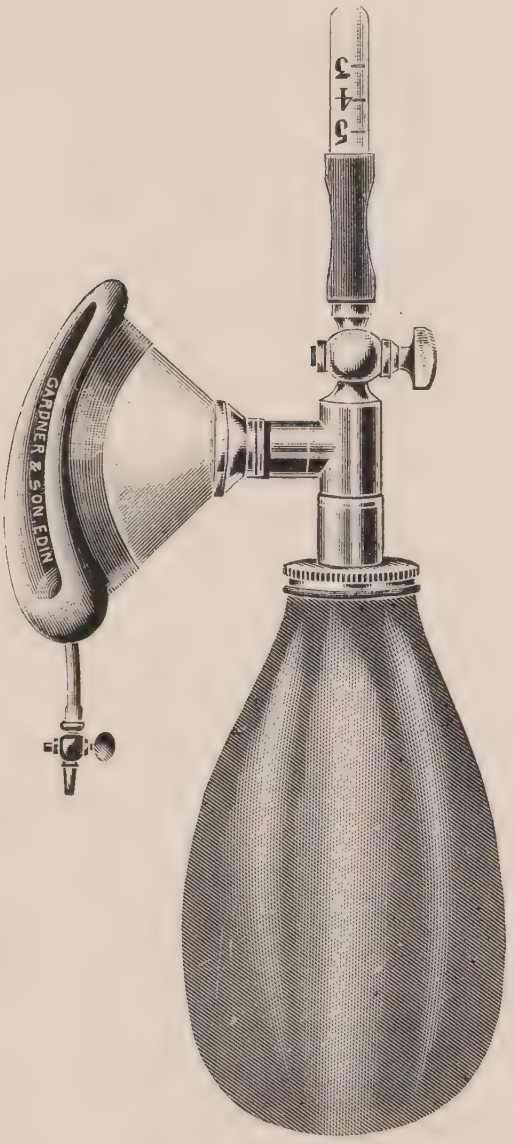


FIG. 18.—DANIELL'S ETHYL CHLORIDE INHALER.

The Guy Inhaler.

In Guy's inhaler there is some little difference in actual structure, although the principle is essentially the same. The apparatus is slightly

more complicated. He uses a Barth three-way tap, which carries a feed-tube mounted on a ball-and-socket joint. Through this tube gas or ethyl chloride is introduced into the bag. Fig. 19 (see p. 111) shows the arrangement. A hole is made half-way up the upper part of the bag-mount; the feed-tube mounted in its ball-and-socket joint is continuous with the hole. In the perpendicular arm of the three-way tap a corresponding hole is made; a pointer on the bag-mount and an arrow-head on the perpendicular arm of the tap serve to show when the two holes are in apposition. As an additional convenience, another hole is made exactly opposite, so that gas or ethyl chloride can be introduced on either side.

Guy has a special glass measure with a base on which it can readily stand. To use this inhaler for ethyl chloride alone, the drug is sprayed into the measure, which is then attached to the tube; the tube should be adjusted in its most dependent position. The pointer of the tap is put at ' No valves,' the face-piece being adjusted to the patient's face; the feed-tube is raised, and the ethyl chloride slowly tilted into the bag. This apparatus can be equally well adapted for the administration of gas, or gas and ether, etc.

It will be seen, then, that to make a thoroughly satisfactory inhaler for ethyl chloride we have to

only slightly modify the parts of an ordinary Clover's inhaler, having put the ether chamber aside. The modifications are such that any instrument-maker can carry them out at a trifling cost; and this is a point of some importance, as many dental and medical practitioners already possess a Clover's inhaler. No part of the inhaler should be made of vulcanite, owing to the tendency of this to perish under the action of ethyl chloride. Either red or black rubber will do for the bag and face-piece, but on the whole the red rubber lasts longer.

Physiology of Ethyl Chloride.

The special points in the physiology of ethyl chloride may briefly be summarized as follows:

1. After a trifling preliminary rise, the effect of the drug is to lower the blood-pressure appreciably. In the human adult subject this fall becomes appreciable when more than 3 c.c. have been given, and when a dose as high as 5 c.c. has been chosen a fall of as much as 30 mm. of Hg is probable. For this reason many authorities dislike administering ethyl chloride in full dosage with the patient in the sitting posture.

2. The cause of the fall of blood-pressure is diminished cardiac output, not dilatation of the vessels.

3. The respiratory centre is at first stimulated, and respiration is therefore deeper than normal. As full anæsthesia develops, respiration quietens down to some extent. It is to be noted, however, that ethyl chloride is for dental purposes always given upon the closed system, rebreathing being practised from the start. The reader is referred to the remarks made upon p. 50 on the subject of CO_2 excess, and is only here reminded that when rebreathing is being practised respiration is always deeper than normal. Continuance of breathing of this type is therefore not a proof that the ethyl chloride is still acting as a stimulant; the deep respiration in the later stage is due, not to the drug, but to excess of CO_2.

In cases where overdosage has occurred, death appears to have taken place by paralysis of the respiratory centre, the heart still showing a little power of contraction after respiration has ceased. There is therefore a fair prospect of recovery if artificial respiration be started promptly.

Preparation of the Patient.

The patient should have abstained from food for a period of not less than two hours prior to the administration of ethyl chloride. If the stomach, rectum, and bladder be not empty beforehand, they are very likely to empty themselves reflexly

during or after the anæsthesia, and this is particularly so in children.

If there be any dentures present in the mouth they should be removed, and anything tight about the neck or corsets should be loosened or taken off. It is a wise precaution in all cases to have heart and lungs examined by the patient's ordinary medical attendant, not so much from the liability of disease being present such as would contra-indicate the use of ethyl chloride and indicate another anæsthetic, but as a means of establishing the patient's confidence and being prepared for any eventuality.

Posture of the Patient.

Under the heading 'Physiology' reference has been made to the question of posture for ethyl chloride administration, but in the author's opinion there is, unless very heavy dosage is being adopted, no real contra-indication to the sitting-up posture, unless the operator prefer the lying-down position; this position is often more suitable for young children, as they are apt to slip down in the chair and collapse in a heap, to the embarrassment of all concerned. When the sitting-up position is utilized, however, the head must not be put too far back, for if this be done the trachea becomes pressed upon by the neck

muscles, and the respiration gets embarrassed. The coronal plane of the head should be in the same vertical as in the spinal column.

The Administration.

The ethyl chloride having been accurately measured, the face-piece is carefully adjusted and the patient told to breathe away quietly to and from the bag. It is essential that the bag shall be moderately inflated before any of the drug is introduced. Hewitt placed so much emphasis upon this point that he provided with his apparatus a hand-bellows attached to the extremity of the bag, by means of which he blew up the bag before the administration. Correct as this may be in theory, in practice it is not essential, for by a little care it is possible to inflate the bag by catching in it one or two expirations of the patient, lifting the mask from the face during the corresponding inspirations.

As regards the introduction of the drug from the glass vial into the rubber bag, one method is to tilt up the vial and tip its contents into the bag either in one movement or preferably in two or three instalments. Dr. J. H. Gibbs of Edinburgh introduced some years ago a very much better method, which is to evaporate the drug by allowing the vial to dip into hot water. This

so-called ' vapour method ' enables one to control the rate at which the anæsthetic is added to the air contents of the bag with great accuracy, since one can observe the violence with which the fluid drug is boiling off, and increase or decrease it at will by immersing the vial in the water more or less.

After about six to eight full breaths the respiration becomes deeper, and the pupils contract somewhat, but they then almost immediately begin to dilate and lose their reaction to light. The pupil is dilated in 40 per cent. of cases, contracted in 8 per cent., and practically unchanged in 52 per cent. (Reboul).

The eyes become fixed in one axis, and the conjunctival reflex is lost.

The signs upon which one relies to indicate overdose are, in order of their appearance:

(1) Total loss of corneal reflex.
(2) Excessive dilatation of the pupil.
(3) Failing respiration.

The muscles become relaxed, as a rule, throughout the body, with the exception of the masseter muscle, which very often goes into spasm. This constitutes one of the drawbacks to the drug, and to avoid waste of time in opening the mouth the use of a mouth-prop inserted prior to the commencement of the inhalation is desirable, just as

in the case of nitrous oxide gas. The pulse is full and bounding, and if a sphygmographic tracing be taken it shows a clearly-defined tidal wave. The patient's face is flushed, and sometimes beads of perspiration appear very soon on the forehead. Unconsciousness supervenes in from 18 to 25 seconds, and on the average a full anæsthesia is obtained in 50·9 seconds, allowing an available period for operating of 71·3 seconds (McCardie).

As regards the stages of anæsthesia, Malherbe and Laval described the following:

1. An analgesic stage, which commences after two or three breaths of the anæsthetic, and lasts thirty seconds or thereabouts.

2. An anæsthetic stage, which lasts from two to three minutes.

3. A second analgesic stage, during which the patient may move and talk, but feels nothing.

The late Dr. Luke had in ethyl chloride great faith and great confidence, and pressed its administration to a point which the present author regards as undesirable. Luke never had a fatality; such trouble as he did meet was respiratory in character. Cyanosis and spasm of the chest muscles came on in certain subjects, especially muscular males, with alarming rapidity, but were not regarded as serious if the anæsthetist kept his head.

"If a wedge or gag be not in the mouth, one is inserted at once, and a free air-way established by means of traction on the tongue, etc., and artificial respiration applied, which, with the withdrawal of the anæsthetic, usually rapidly restores the patient's respiratory equilibrium and normal colour" (Luke).

The present author regards a dose of 5 c.c. to an adult as large, and rarely exceeds 4 c.c.; he much prefers to use the drug in even smaller doses, combined with nitrous oxide and oxygen (see p. 110). He also has a profound belief in Gibb's 'vapour method,' and regards any other as very crude save when using very minute doses.

After-Effects.

The after-effects vary considerably in different subjects. They are also, of course, affected by the length of the administration.

Vomiting is the most common and most unpleasant sequela, occurring in 15 to 20 per cent. of cases, and nausea in a greater percentage.

As regards the character of the sickness, it resembles that which is seen after ether anæsthesia, violent while it lasts and of short duration. It is often over in fifteen minutes, and anything longer than three to four hours is quite exceptional. McCardie records one case of thirty hours. As

noted elsewhere, sickness and nausea are much less common when nitrous oxide or oxygen is given along with the ethyl chloride.

A great deal depends on the manner in which the patients have been prepared, and, in short, whether they have had a meal recently or not. Patients who have come from a distance and who are anæsthetized late in the day are more commonly upset than those who are dealt with in the morning after a light meal taken early.

A few cases of acidosis in children have been reported as occurring after ethyl chloride. This very dangerous complication comes to notice some twelve to twenty-four hours after the administration, and is heralded by a return of severe vomiting, which soon begins to show evidence of the presence of altered blood. First delirium and later coma show how profoundly the nervous system is poisoned, and in fatal cases the child dies in twenty-four to seventy-two hours after the symptoms have begun. This condition is fortunately a rare one. For an account of its interesting pathology the reader is referred to any textbook of medicine or of surgical anæsthesia.

Hysterical symptoms are fairly common with young girls, associated with profuse lachrymation on regaining consciousness.

The drug has a distinct tendency to promote

erotic thoughts and dreams, and even sensuous movements of the patient's limbs, etc., while in the semi-anæsthetic state. Subsequent accusations by females of indecent assault have been recorded. Marshall of Liverpool mentions two such cases, and McCardie another.

Fainting and collapse are seen at times, but are usually associated with vomiting, etc. Jaundice is uncommon as a late sequela, but some cases have been noted in Paris. Albuminuria is unknown in healthy people, except after prolonged narcoses of half an hour or more. Fatty degeneration of the liver and kidneys has been noticed after repeated administration.

General Conclusions as regards Ethyl Chloride for General Anæsthesia.

1. It is rapid and pleasant in action, and a very portable substance.

2. As regards period available for operative procedure, it compares very favourably with nitrous oxide.

3. It causes little or no cyanosis under ordinary circumstances. If this is noticeable, it is either due to excessive rebreathing or to commencing respiratory spasm.

4. The administration is very simple in technique.

5. The drug is reasonably safe if due precaution is taken, and perhaps in the hands of those who are not constantly giving anæsthetics may be said to be the safest anæsthetic for short anæsthesias. In no respect, however, can it be said to compare favourably with nitrous oxide and oxygen given by an expert. So far as dental work is concerned the author personally limits its use to the method described on p. 100 *et seq.*, where it is employed as an adjuvant to nitrous oxide and oxygen.

6. Although vomiting is fairly frequent, it is rarely followed by any severe after-effects.

7. It is cheaper than nitrous oxide, and, of course, infinitely more portable and convenient in the country.

8. In the class of patients who suffer from an unduly high blood-pressure, it is certainly to be preferred to nitrous oxide given by itself. Even if nitrous oxide with oxygen is available, there are certain of these cases to whom one would, upon the whole, prefer to give ethyl chloride.

9. The somewhat sickly odour is objected to by a few patients, but may be disguised by a little perfume.

10. While in certain subjects the degree of after-sickness is a serious drawback (modified by adequate preparation), and the indiscriminate

and haphazard manner in which ethyl chloride was administered all over the country by unqualified and irresponsible persons threatened at one time to bring the drug into disrepute from the occurrence of a considerable number of fatalities, we are, with the reservations already mentioned, of the opinion that ethyl chloride, administered skilfully with all due precautions, is a safe and in many ways admirable anæsthetic. For some reason it hardly ever gained the appreciation in London which it has acquired in the provinces and abroad, but that it is now largely used with advantage where formerly either chloroform or ether would have been considered indispensable there is no doubt. It must be put into a quite different category, however, from nitrous oxide as regards safety.

It should be avoided in advanced pregnancy, the very obese, or those with large abdominal tumours, and in any condition involving constriction of the air-passages: all for the same reason—viz., that respiratory difficulties are specially liable to arise here, and the trouble we have with this drug is usually respiratory rather than circulatory.

Nitrous Oxide and Ethyl Chloride in Sequence.

Dr. Guy introduced this method in the early days of ethyl chloride anæsthesia. He was struck with the value of the new agent as a single-dose anæsthetic for dental work, but could not dismiss from his mind the fact then obvious from a perusal of current literature that accidents sometimes happened under ethyl chloride. Before teaching the use of the new drug to his students, he was therefore resolved to find a method which would eliminate the element of risk. After experiment he found that if preceded and mixed with nitrous oxide gas, the dose of ethyl chloride requisite to secure an anæsthesia of reasonable duration was much reduced. He judged that in this discovery he had found a means to reduce the risk to nil, and subsequent experience, extending over many years and tens of thousands of cases, has absolutely justified the attitude he assumed.

To render practicable his method, Dr. Guy designed his modification of the Barth three-way gas-tap to which reference has already been made on p. 98. When the Guy inhaler is used for the designer's nitrous oxide-ethyl chloride sequence, the N_2O is admitted by the feed-tube

attached to the angle-mount by a ball-and-socket joint. In the perpendicular part of the three-way tap there is a hole marked with an

FIG. 19.—GUY'S INHALER FOR GAS AND ETHYL CHLORIDE.

arrow, and when this corresponds with the pointer in the bag-mount the holes in the latter are in exact register.

FIFTY CASES OF GAS AND ETHYL CHLORIDE ANÆSTHESIA (GUY'S METHOD).

Number.	Patient (Sex and Age).	Duration of Inhalation.		Available Anæsthesia.	Ethyl Chloride Used.	Teeth Extracted.	Phonation.	Pupil.	Cyanosis.	Stertor.	Remarks.
		Gas.	Gas and E.C.								
		secs.	secs.	secs.	c.c.						
1	M. 16	25	45	75	3	7	o	5 mm.	o	o	Large bag; indeterminate quantity of gas, 1-2 galls.
2	F. 25	25	45	45	3	5	o	4 ,,	o	o	—
3	F. 23	25	50	60	3	1	going under	4 ,,	o	o	—
4	F. 25	25	65	75	3	15	,, ,,	4 ,,	o	o	—
5	F. 17	30	30	45	3	3	,, ,,	4 ,,	yes	o	One breath of air admitted.
6	M. 23	15	50	60	3	5	,, ,,	normal	o	o	—
7	F. 15	25	45	65	3	2	o	,,	slight	o	One breath of air admitted.
8	F. 19	10	40	80	3	3	yes	4 mm.	o	o	—
9	F. 14	15	35	60	3	8	o	4 ,,	yes	o	—
10	F. 21	10	40	80	3	8	o	4 ,,	slight	o	—
11	F. 18	10	50	85	3	4	o	normal	,,	o	—
12	F. 24	10	90	85	3	9	yes	,,	,,	o	—
13	F. 25	10	80	90	3	8	o	4 mm.	,,	o	—
14	F. 23	10	75	35	2	2	yes	normal	,,	o	—
15	F. 21	15	60	60	3	3	o	4 mm.	,,	o	Hysterical patient.
16	F. 23	10	55	80	3	12	yes	4 ,,	,,	o	—
17	F. 16	10	50	60	3	2	,,	5 ,,	o	o	Very anæmic.
18	F. 16	10	45	80	3	3	o	4 ,,	o	o	—
19	F. 16	10	40	60	3	2	o	5 ,,	slight	o	Small bag; 1 gall. of gas.
20	F. 17	15	90	60	3	3	o	5 ,,	o	o	—
21	F. 30	10	53	75	3	12	o	5 ,,	slight	o	—
22	M. 14	10	50	65	3	5	o	normal	o	o	—
23	F. 15	10	50	70	3	7	o	5 mm.	very slight	very slight	—
24	F. 20	10	40	60	3	6	o	4 ,,	o	o	Phthisic.
25	F. 33	10	50	70	3	5	o	4 ,,	o	o	—

							yes	5 ,,	yes	slight	—
27	F. 21	10	40	75	3	2	o	5 ,,	slight	o	Involuntary micturition.
28	F. 21	10	75	90	3	2	o	5 ,,	,,	o	—
29	F. 22	10	40	65	3	3	o	5 ,,	,,	o	—
30	M. 21	10	55 40*	35 150	3 5	19 19	o o	4 ,, 4 ,,	yes ,,	yes ,,	Marked muscular rigidity. ,, ,, ,,
31	M. 20	10 air	40 45 45	85	5	6	o	4 ,,	slight	o	Tongue fell back, obstructing respiration at 40 secs.
32	F. 20	10	45	100	3	5	yes	4 ,,	o	slight	—
33	M. 25	10	60	65	5	11	o	5 ,,	slight	,,	—
34	F. 18	10	50	70	3	6	yes	4 ,,	o	,,	—
35	F. 15	10	45	70	3	4	o	5 ,,	slight	o	—
36	F. 19	15	45	80	3	8	o	5 ,,	,,	o	—
37	F. 22	15	55	95	3	9	o	5 ,,	o	o	—
38	F. 47	15	50	85	3	12	o	4 ,,	yes	o	Air at 35 secs., Hewitt's apparatus.
39	M. 22	10	40	70	3	1	o	4 ,,	slight	o	—
40	F. 50	10	65	120	5	12	o	5 ,,	o	o	Anæmic woman.
41	M. 38	15	65	70	5	9	o	normal	yes	o	—
42	F. 26	15	50	55	3	14	yes	5 mm.	slight	o	Breath of air at 40 secs. Feeble, neurotic.
43	F. 18	15	65	60	3	12	,,	5 ,,	,,	o	—
44	F. 31	15	60	60	3	9	,,	4 ,,	yes	yes	—
45	F. 22	15	90	120	3	18	,,	4 ,,	,,	,,	Breath of air at 50 secs. Considerable outcry and resistance, but complete analgesia.
46	F. 19	15	65	70	3	9	o	4 ,,	slight	,,	Breath of air at 40 secs.
47	F. 18	15	45	60	3	4	o	4 ,,	yes	o	—
48	F. 14	15	25	60	3	3	o	normal	o	o	—
49	F. 22	15	55	65	3	6	yes	4 mm.	slight	o	—
50	F. 17	15	65	65	3	9	,,	4 ,,	,,	o	Breath of air at 50 secs. Great outcry, but analgesic; very noisy during administration.

* Re-applied ethyl chloride.

In using the apparatus, the tap is turned to 'Air.' Gas is let into the bag until it is full, and the bag-mount is turned around a quarter of a circle to close the outlet. The gas-supply is now disconnected. The ethyl chloride tube, kept in the dependent position, is now attached to the feed-tube.

The face-piece having been carefully adjusted to the face, at the end of an expiration the tap is turned to 'No valves.' After six complete respirations the ethyl chloride supply-tube is tilted up and the drug poured into the bag.

The patient is then allowed to breathe the mixture for from twenty-five to thirty seconds, and should then be ready for the operation to begin. Time spent in holding the breath by nervous patients, or those who find the smell unpleasantly pungent, must not be counted. During the twenty-five seconds mentioned the patient should be actively breathing. The amount of ethyl chloride introduced into the bag should never exceed 4 c.c., and rarely be more than 3 c.c. For the very large majority of adult cases this will be sufficient. Children require a smaller dose—say, 1 to 2 c.c. It is important that the bag be dry, and that the temperature of the operating-room not below 60° F.

This mixture is a single-dose anæsthetic, and should not be repeated at a sitting, or sickness is certain to result.

For those who give dental anæsthetic rarely this method remains as one of very great value because of its extreme simplicity, but it does not give such good results as the nitrous oxide, oxygen, and ethyl chloride method described on p. 160, which was developed from Guy's original nitrous oxide and ethyl chloride sequence.

CHAPTER V

ETHER, AND ITS COMBINATIONS

ETHER was probably discovered chemically by Michael Faraday, but Crawford W. Long first used it as an anæsthetic in 1843. He appears to have not thought very much about it, however, as he left it to Morton to claim the credit some three years later.

Ether is a very volatile, highly inflammable liquid devoid of colour, but with a peculiarly characteristic odour and hot taste. It contains about 8 per cent. of spirit, and boils at 100° F. The specific gravity varies slightly, according to the purity, the range being 0·720 to 0·735.

Crude methylated ether is unsuitable for anæsthetic purposes, but good ether can be prepared from it, known as 'æther purificatus.' Ether prepared from pure ethylic alcohol is really unnecessarily expensive when this variety can be obtained.

Recent chemical research by Wallis has established the fact that absolutely pure ether has very little anæsthetic power, and that the effects

ordinarily produced by 'ether' as supplied by even the best makers are due to certain other ingredients—impurities in one sense, if one can so designate substances so essential to our work. Of these, the most important are ethylene and the higher ketones, and Wallis prepared a solution of these in pure ethylic ether, with the addition of CO_2, which adds to their activity. This preparation was tried on human subjects by Langton Hewer, who reported so favourably upon its action that it has been placed on the market by Messrs. Savory and Moore under the name of Ethanesal. It may be used instead of ether, and is said to give good results, less of the drug being required than in the case of ether, and less after-nausea being produced.

Open methods of administering ether are not suitable for dental work, and the closed method only will be described.

The Closed Method.

The essential appliances for the closed method are (1) a good face-piece; (2) some closed chamber of varying type for containing the liquid ether; and (3) the ultimate bag (1 gallon) from which the patient inhales the mixture of ether and air in varying percentage.

Several inhalers conform to these requisites.

Ormsby's, Clement Lucas's (with a simple glass chamber and contained sponge), Bellamy Gardner's, Hewitt's, and Clover's.

For all practical purposes we may eliminate the first three, as for one occasion on which they are used Clover's is used fifty times and Hewitt's five times at the very least.

Clover's inhaler was brought out in 1877, and has been *facile princeps* ever since. While the wide bore in that devised by Hewitt has an advantage in allowing of freer breathing in some ways, taking it all round, Clover's is *the best apparatus for the closed administration of ether ever devised*, and the principle adopted in Hewitt's is, of course, the same. It is essential to procure one from a reliable high-class instrument-maker, and not a cheap type, the bore of which is usually narrow and the instrument sometimes defective in other ways.

The actual fixing on of the face-piece by a screw attachment in Hewitt's marks an advance, and the face itself is a very good and durable one. Some face-pieces for Clover's inhaler are badly designed, and calculated to allow of leakage.

The body of the inhaler (see Fig. 20) consists of a spherical metal ether chamber, upon one hemisphere of which is fixed a water-jacket to render the temperature as constant as possible.

The jacket takes the form of a cylindrical extension. The chamber is provided with an aperture for introducing the ether, to which is fitted a vulcanite stopper enclosing a glass bulb indicator.

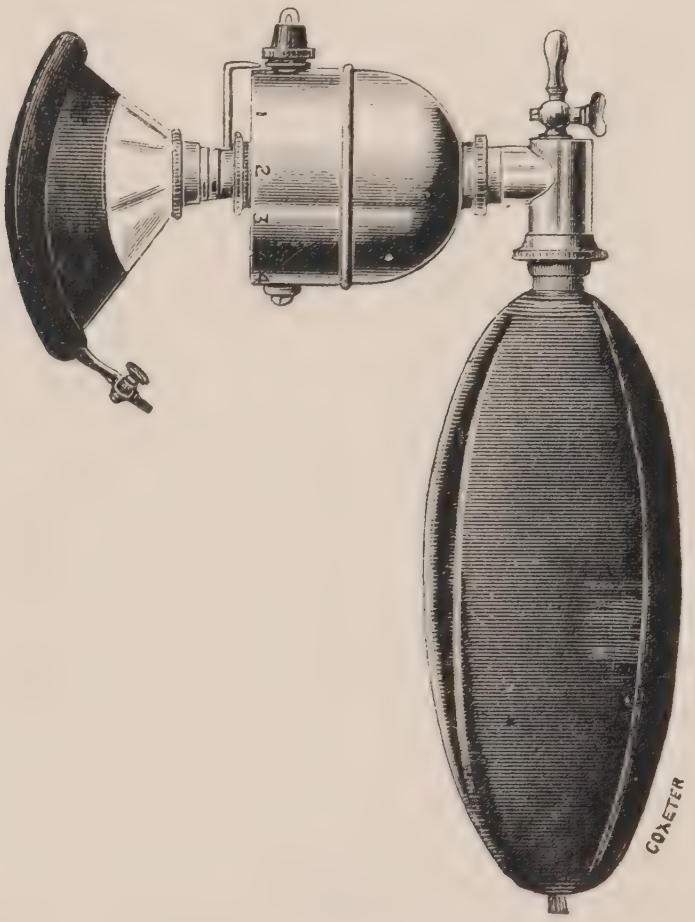


FIG. 20.—CLOVER'S INHALER.

When the bulb is in the dependent position, the ether, if any remain in the chamber, is seen to be there.

Water-jacket and chamber alike are pierced by a central tube, which has a slot cut in it about one-third of the distance from either end, giving access in this way to the ether contained. Just opposite these slots the tube (the metal of which is continuous with that of the chamber) is of larger bore than elsewhere.

A separate metal tube distinct from the chamber is accurately fitted into this tube or outer sheath with slots which correspond to those above mentioned, but between them a metal diaphragm occludes the lumen of the tube. This inner tube is continuous on the one hand with the face-piece, and on the other with the rubber bag.

Fixed on the inner tube between the face-piece and the water-jacket is a stout wire indicator which points at figures marked on the surface of the water-jacket, indicating very roughly the strength of the vapour used. It really refers to the degree of coaptation between the slots in the inner and outer tube, and when they completely correspond stands at *F*, or full. At this point all the air inspired from the bag by the patient passes over the ether contained in the metal chamber, and is strongly impregnated with ether, so much so as to be practically irrespirable except by a semi-unconscious patient. At *O* the tubes do not coapt at all, but all the ether is shut in the metal con-

tainer, none getting into the patient's lungs. It cannot get past the metal diaphragm, but uses the expansion before mentioned in the outer tube, which is a sort of by-pass; 1, 2, 3, express varying degrees of coaptation.

HEWITT'S INHALER.—This differs from Clover's pattern in the following particulars (see Fig. 21):

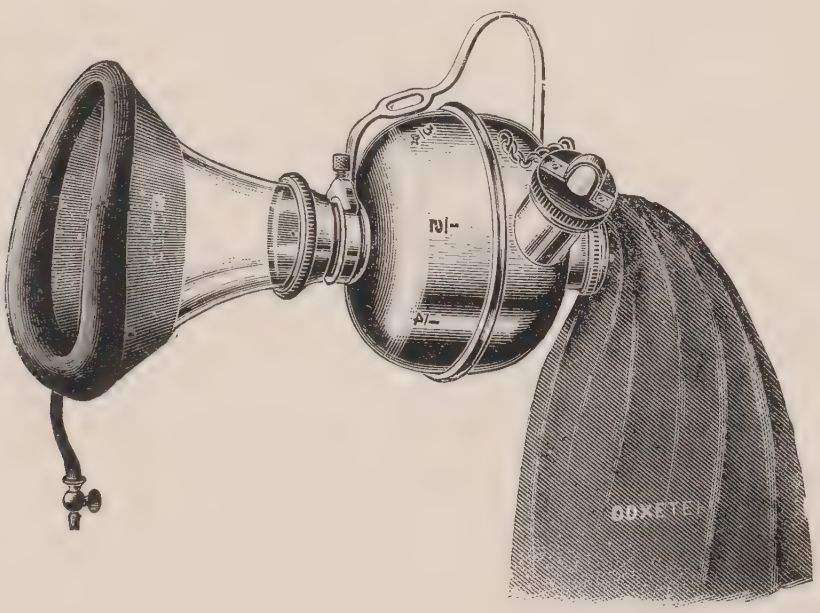


FIG. 21.—HEWITT'S INHALER.

1. The internal calibre is very much larger—indeed, about twice the size of the Clover.

2. The central tube rotates within the fixed ether reservoir, instead of the ether chamber rotating, as in the Clover inhaler.

3. The face-piece is screwed on—a distinct

advance, especially with nervous and alcoholic patients who struggle.

4. The ether reservoir can be adjusted whatever the position of the patient, so that fresh ether can be added without suspending the administration by removing the face-piece from the patient. The inner tube is in two sections, which are made to revolve simultaneously by means of the handle, which is loop-shaped, with an arm fixed in each.

With this apparatus there is less tendency, especially when the administrator is inexperienced, of stertor, cyanosis, and laboured breathing. It has not, however, generally displaced the Clover, chiefly, probably, as it is rather more expensive.

The Administration of Ether by the Closed Method.

Where possible, it is usually desirable to start ether anæsthesia by rendering the patient unconscious with nitrous oxide (see p. 125), or by a small amount (2 to 3 c.c.) of ethyl chloride (see p. 131); but with plain ether anæsthesia is very easily and rapidly induced in a Clover's inhaler by any adequately trained anæsthetist without undue discomfort to the patient. The vapour is, of course, fairly pungent, and the smell long remembered, and usually detested after the event; but it is for the administrator to see that

the vapour strength is carefully graduated so as to cause as little coughing and holding of the breath as possible.

The inhaler is first charged with the necessary amount of ether—for dental work ½ ounce usually being more than sufficient—the index set at *P*, and any ether vapour carefully blown out of the tube.

The face-piece is then carefully adapted to the patient's face. Care must be taken there is no leakage at the upper extremity over the bridge of the nose, where it is most liable to occur, except in the case of people with beards, when it is always difficult to prevent.

In strong-jawed muscular types, especially if there are no gaps in the front teeth already, it is best to start with a small mouth-prop, in order to allow of the mouth being readily opened with a gag.

To start, one or two breaths are caught in the bag, or the patient asked to blow into it, and then the index is moved a small fraction from zero towards 1.

If the patient breathes away comfortably it is again advanced, and again, until 1 is reached. If the breath is held and the vapour seems too strong for the patient at any point, the index needle should be switched back ½ inch or more

and a few breaths allowed of the weaker vapour, and then another advance made. The principle is *reculer pour le mieux sauter*. After such a withdrawal very often a more rapid advance can be made, and the patient quickly becomes tolerant of stronger vapours, and anæsthetized.

Unless the vapour strength be increased only with discretion and caution, delay is bound to occur, also very undesirable salivation.

Once anæsthesia is established and the pupil fairly dilated ($3\frac{1}{2}$ to $4\frac{1}{2}$ millimetres), one breath of air to three or four of ether may be usually allowed on principle.

After-Effects of Ether.

Sickness is rather more common than after chloroform, but very transient. Some ether-impregnated mucus and blood may be rejected in a few bouts of retching, and then the patient quickly recovers. It is always best that blood should be vomited, as it keeps the patient dull and upset in his digestion if retained for long. Care must be taken not to give ether to people with marked naso-pharyngeal catarrh or tendency to bronchitis. Ether bronchitis and pneumonia are rare, however, in healthy subjects.*

* Mucus during ether anæsthesia and bronchitis after it can be reduced by giving $\frac{1}{100}$ gr. atropine sulphate half an hour before administration.

Certain people get very excited after ether, alcoholics and hysterical women in particular, and some restraint in such cases may be needed for a while.

Ether given in Sequence.

In actual practice, ether by Clover's method is nearly always preceded either by ethyl chloride or nitrous oxide.

Nitrous Oxide and Ether Sequence.

The apparatus required is as follows:

A Clover's portable inhaler, with a good medium-sized Barth's face-piece and a 2-gallon gas-bag fitted with an ordinary three-way stop-cock; 4 or 5 feet of $\frac{1}{2}$-inch stout rubber tubing joining the lower end of the gas-bag to the nozzle of a two-bottle (angle pattern) gas-stand fitted with pedal keys.

Ether is introduccd into the chamber of the Clover, $1\frac{1}{2}$ ounces only being required. During the process it is well to turn the indicator to '2' or '3'; if it be at zero, the fluid ether is apt to bubble back or actually spurt up into one's face.

The 2-gallon bag is squeezed empty by the hand, and nitrous oxide turned on by the foot. The gas-tap, which has so far stood at 'Valves,' is pushed back to 'Air,' so as to close the mouth

of the bag, and allow it to distend to a moderate degree.

Having taken the usual precautions as regards position of patient, insertion of mouth-prop, and so forth, we now adapt the face-piece carefully to the face, and allow the patient to breathe quietly with the tap still at 'Air.' Once the subject has become habituated to the feel of the mask, the tap is turned to 'Valves,' and in this position some six breaths of the patient will half empty the bag. During this stage most of the air in the face-piece and the upper air-passages will be washed out. Prolonged valvular breathing is not necessary, since we are not going to depend for our anæsthesia upon nitrous oxide alone; and the patient need not therefore be deprived of all traces of oxygen in the atmosphere. We now push the tap over to 'No valves' and begin rebreathing. If desired, the nitrous oxide cylinder may now be opened again by the foot-key, and the volume of the bag contents restored.

After a further few breaths we may begin to turn on the ether with some confidence that the patient's sensibilities will have been so lowered by the gas that he will not detect the unpleasant odour of the ether, always provided we increase it very gently.

For dental purposes we must remember that

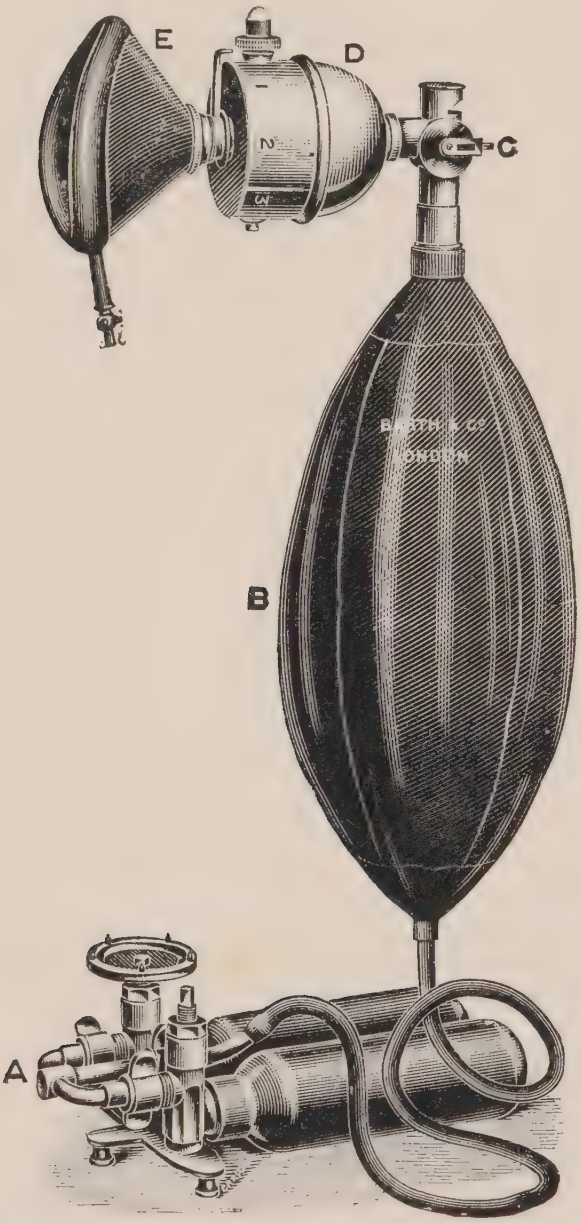


FIG. 22.—GAS AND ETHER APPARATUS.

our object is to ensure the absorption of a reasonable dose of ether which will induce in the patient

a fairly deep anæsthesia, and the elimination of which, after the mask has been lifted, will not be too rapid. The dental surgeon will, of course, supply his anæsthetist with a rough estimate of the time he will require, and the exact technique of the administration will be chosen largely to meet this need, having always in view the fact that the deeper the etherization, the more unpleasant the after-effects. Personally, the author believes that the best results are obtained by advancing the ether indicator to '2' or '3' at most; if a long period of working anæsthesia is desired, he prefers to lengthen the period during which the patient breathes the ether, rather than to push the indicator to 'Full.'

During the induction, one must not tolerate any undue lividity, and there need be no hesitation about pushing the valve tap back to 'Air' and allowing the patient to get one or two breaths of fresh air along the tube of the Clover. This manœuvre may be repeated at intervals of, say, fifteen seconds throughout the later stages of the induction. It must not be practised too soon, however, or the patient may struggle.

The establishment of anæsthesia may be recognized from the loss of conjunctival reflex (the patient does not 'wink' when his eyeball is touched), from regular automatic breathing, a

more or less dilated pupil, and muscular flaccidity, the arm dropping limply at the patient's side if raised and let go. Very robust men, alcoholics, and hysterical or neurotic females are not usually good subjects for gas and ether, for they sometimes get excited when half 'over,' and struggle violently or shout and scream. With a little care, however, these demonstrations may be avoided by anticipating them, and getting the patient more fully under the gas before turning on ether.

Guy's technique differs somewhat from that described; he begins rebreathing from the very first, and pushes his ether on much more rapidly, reaching the point of full ether very speedily. It must, however, be taken into consideration that his methods of extraction do not call for prolonged periods of working anæsthesia. Himself an extractor of almost uncanny speed and precision, he teaches his students to lose no time, and to do only what can be done in reasonable time, leaving anything which cannot to another occasion. A point such as this is more for the dentist than the anæsthetist, and the needs and methods of the operator must necessarily reflect on the methods of anæsthesia chosen.

The duration of the anæsthesia is an entirely variable quantity, and will depend on the duration of the administration, the amount of ether

inhaled, and the type and constitution of the patient.

If the administration be properly conducted,

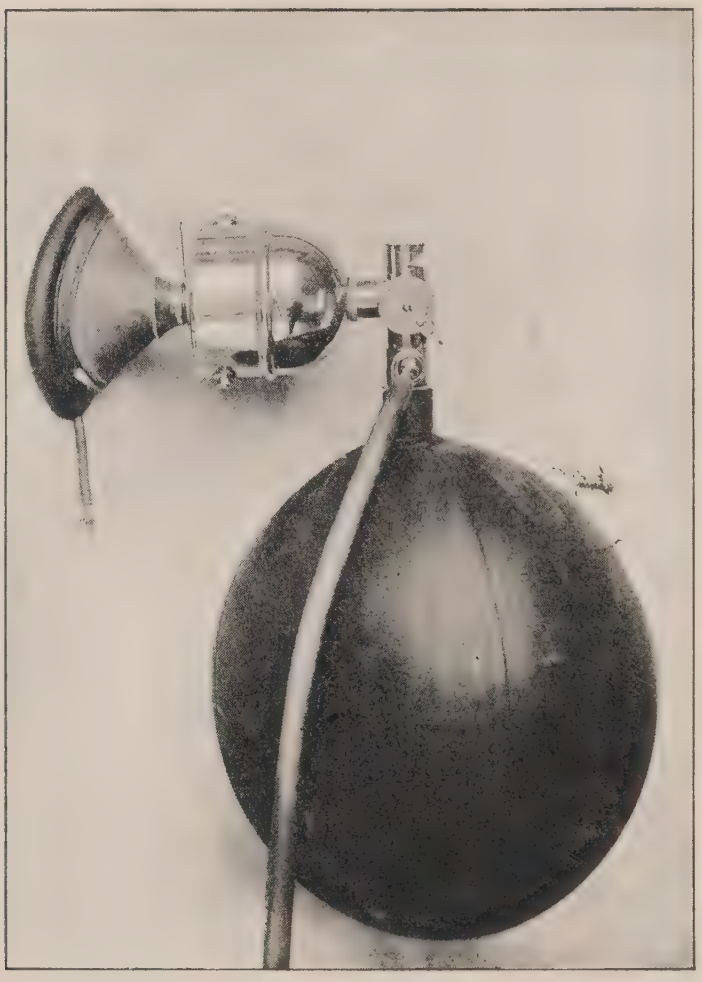


FIG. 23.—GUY'S ARRANGEMENT FOR ADMINISTERING GAS AND ETHER.

and one minute and a quarter to one minute and a half be allowed to elapse from the moment of the adaptation of the face-piece, an anæsthesia of at

least a minute should be available, allowing sufficient time for a moderately expert dentist to extract a couple of difficult teeth or six or seven easy ones. It is always well to leave some margin, however, and the 'gas and ether sequence' may be administered for two, three, four, five, or ten minutes, according to the time which it is expected the extractions will take to effect. Of course, when the ether is pushed in this way, the patient passes into a condition of deep anæsthesia, and the responsibility of the case becomes so much the greater.

Nitrous oxide and ether is a method not commonly called for in dental work, since nitrous oxide-oxygen-ethyl chloride is capable of meeting most cases met with. More and more will it tend to be displaced by more modern methods, especially nasal gas and oxygen. It remains, however, at present as still necessary to be described, since a few cases are met with which can hardly be met in any other way.

The Ethyl Chloride and Ether Sequence.

The chief advantage which this combination possesses over gas and ether is the greater portability of ethyl chloride compared with nitrous oxide gas. The apparatus itself is, of course, much less bulky also, simply consisting of a Clover's

inhaler, with the slight modification already described for introducing the ethyl chloride.

This sequence is somewhat easier to give than 'gas and ether'; but in deciding between the two methods it must be remembered that 'gas,' being tasteless, is more agreeable to the patient as the first member of a sequence than the rather sickly smelling ethyl chloride, and that 'gas and ether' holds a long and unrivalled record for almost absolute immunity from fatalities.

Since all that we ask of the ethyl chloride is that it shall prepare the patient for rapid etherization, we do not use a large dose unless faced with a powerfully built man suspected of alcoholism or convicted thereof by the results observed in previous administrations. For the ordinary type, 2 c.c., or at most 3 c.c., of ethyl chloride is ample, and it should be given by Gibbs's 'vapour method' referred to on p. 102.

The ether may be turned on as soon as the ethyl chloride has about half evaporated. As to the remainder of the induction, there is little to add to the remarks made upon gas-ether. As already said, this method is of the two much easier, since the ethyl chloride, even in small doses, seems to prepare the way for ether more thoroughly than does nitrous oxide; there is, moreover, much less cyanosis to contend with.

CHAPTER VI

CHLOROFORM

THE practice of using this drug as the anæsthetic of choice, even in dental work, was, until recently, widespread in this country, particularly in its northern portion. Some of the better and safer drugs and methods, as elsewhere described in this book, have been available for several decades, and yet chloroform was by many practitioners still habitually used. They had been taught it in their student days, and even the unfortunate 'accidents' which occurred in the hands of themselves and their neighbours, or were reported in the public press, seemed inadequate to sting them into the effort necessary to learn some newer method really suitable for dental work. Better education in the schools is at last taking effect, and it is only in the more remote country districts or in very poor class practice in certain towns that chloroform is now widely given for the extraction of teeth. Moreover, when given at all, chloroform is always administered by a medical practitioner who has presumably received

instruction in his student days in some proper method, and who is acquainted with its dangers and the most hopeful lines to take for their prevention. Bearing all this in mind, it would be illogical to include in a book such as this any detailed account of the elementary principles upon which we administer chloroform. There will, however, always be the odd case where, from some peculiarity either in the patient or in the circumstances attending the proposed dental operation, chloroform may be regarded by the doctor as the most suitable anæsthetic, and as the one, therefore, to be chosen in spite of its known risks. A few general remarks about the modern views upon chloroform and its administration may therefore be of some use in assisting a doctor who has reached, or nearly reached, such a conclusion anent one of his patients.

Briefly, we may say that the main advantage of chloroform is that it is easy to give (or at any rate apparently easy), while the main disadvantage is its exceptionally high death-rate. It is worth a moment's reflection to find, if possible, a reason why chloroform has been practically displaced from dental work while still given for many major surgical operations. Firstly, the dangers of the drug are likely to deter men from

giving it in a class of work which should in itself present no danger at all, while still retaining it for the other class of work where there is admittedly an appreciable death-rate from the operation itself, and where the risks of the anæsthetic are somewhat dwarfed by those arising from matters outside the scope of the anæsthetist. If a death from chloroform happens, say, in a case submitted to a very severe abdominal operation absolutely necessary to save life, there is always the comforting thought that the risks run were entirely justified in order to give the patient a fighting chance, and the little point that chloroform may have been given when ether might have made things quite as easy for the surgeon and perceptibly safer for the patient may escape attention. Far different is the case where death has occurred in a patient who only wanted a tooth out. The real criminal here stands in a most unwelcome limelight. This point needs no further discussion or emphasis.

There is, however, much reason to think that not only is chloroform less easily justified, but that it is really and absolutely more dangerous in dental than in surgical work. It is not proposed to attempt the proof of this by statistics; in anæsthetic matters these are notoriously difficult to obtain, and still more difficult to

assess fairly. But if we look into the physiology of chloroform we shall, the author believes, find that in general anæsthesia as given for extraction of teeth nearly every factor now known to increase the dangers of chloroform is present.

The Physiology of Chloroform.

What we may term the normal physiological action of chloroform as ordinarily given has been much studied, more especially with reference to the effects produced by the drug upon the circulation and respiration. Put very briefly, the drug produces a steady diminution of the arterial blood-pressure, and if continued for long enough, finally causes arrest of the respiratory act. The respiration usually ceases before the blood-pressure is reduced anywhere near to zero, and there is therefore usually some remains of circulation at the time when the breathing stops. After much controversy it is now generally accepted that the cause of the fall of blood-pressure is weakening of the heart muscle, and that the cause of the respiratory failure is partly the reduced amount of blood carried to the respiratory centre by the failing circulation (with consequent gradual production of anoxæmia of the centre), but also, and probably chiefly, by the gradual poisoning of the nerve cells themselves.

To meet the only danger so far mentioned, then, it would be sufficient to follow the old directions given by Syme and his pupils of the Edinburgh School. They taught that the main thing was to watch the respiration; to see that the patient had a free air-way and was using it. As additional precautions, they advised us to watch the corneal reflex, not permitting it to disappear entirely, and to watch the pupil to see that it did not dilate and lose its contractility to light; some of them even thought to mention that the colour of the patient must remain good. But it was upon the respiration that they laid all the emphasis, and to it they looked to give warning of any and every danger. Sound as are these rules for the guidance of the administrator of chloroform, there was in the whole argument a fatal gap. These rules will safeguard us from the *ordinary* risks of chloroform—from the results of what one may term gradual overdosage. The fact, however, that by following them we do not attain immunity from accident is in itself proof that gradual overdosage is not the real source of danger; there must, in fact, have been a flaw in the premises to produce so great an error in the conclusion.

If we search the clinical records and the published results of laboratory workers, we shall not

be long before we can put our finger on the weak spot in the arguments of Syme and his school. Chloroform does *not* always work in the gradual way above described; warning from a failing respiration is *not* always given before the circulation is hopelessly damaged. To take first the clinical evidence, the reader may with much profit examine the detailed records on the accompanying tables (drawn from a paper by the late Sir F. Hewitt) of nineteen fatalities caused by chloroform given for the extraction of teeth. Where in these cases do we find any corroboration of the view that a failing respiration will always give timely warning of a failing circulation? Upon what points in the tables can one rely as proof that if a free air-way had been kept no accident would have happened? It is obvious that in each case the circulatory failure was very sudden, and in two cases only is there the faintest indication that any respiratory obstruction existed. In Case 11 we read that 'artificial respiration could not be established,' and it may be that the reporter means that the glottis was in spasm, and the air would, therefore, not enter, though he does not say so very clearly. Again, in Case 15 we are told that the patient was 'cyanosed'; so is anyone the right side of whose heart is failing.

NINETEEN FATALITIES UNDER CHLOROFORM ADMINISTERED FOR THE EXTRACTION OF TEETH.

Classes.	*No.*	*Sex.*	*Age.*	*General Condition.*	*Preparation.*	*Posture.*	*Method and Quantity.*	*Nature of Operation.*	*Relation of Dangerous Symptoms to Operation.*	*Phenomena during Administration and Operation.*	*Fatal Phenomena.*	*Post-mortem.*
Class 1.—Cases in which the dangerous phenomena came on during a deep anæsthesia.	1	F.	21	Of a nervous temperament.	Examined, and chloroform found admissible.	?	Folded napkin.	Large number of roots to be removed. Six or eight extracted.	During.	Longer time than usual to produce anæsthesia. When deeply anæsthetized six or eight lower roots removed.	After six or eight roots removed, pallor observed and no pulse could be felt. No heart action detectable. Breathing then ceased.	?
	2	F.	About 35	Thin and spare; accustomed to faint.	Clothing loose. No breakfast. Operation 11.30 a.m.	Recumbent in a chair-bed with a cushion beneath shoulders; otherwise quite flat.	On napkin.	For the removal of several loose teeth. Operation nearly finished.	Do.	Placed thoroughly under the influence of chloroform. About one-third total number of teeth removed. More chloroform given. More teeth removed. Everything apparently going well. More chloroform given. Very little hæmorrhage observed during operation.	After last dose of chloroform given, colour suddenly left face and patient collapsed.	All organs healthy.
	3	F.	About 21	'Not over-robust looking.'	?	?	?	Eighteen upper and lower roots to be removed. Three extracted.	Do.	Difficult to obtain anæsthesia. Operation begun when patient thoroughly under.	Whilst fourth root was being removed a death-like, bluish pallor swept over face.	None.
Class 2.—Cases in which the dangerous phenomena came on during a light anæsthesia.	4	F.	24	Very nervous and excitable.	'Every care taken.' Corsets loosened. Heart examined.	Reclining in a low easy-chair with head thrown well backwards by means of pillow under back.	40 or 50 min. on lint.	For removal of several teeth. Operation not begun.	Before.	Inhaled about 'three times.' Slipped forwards in chair. Head dropped forwards.	When she slipped forwards, pulse and breathing were both found to have stopped.	?
	5	F.	37	Healthy looking, stout, rather nervous. Had had severe neuralgia for two years. Heart sounds clear. Pulse good.	Corsets and clothes thoroughly loosened. Patient 'examined.'	Semi-recumbent in lowered dental chair.	℥ss. used on Skinner's inhaler.	? Proposed operation. Operation not begun.	Do.	Respirations free and easy.	After 30 drops had been given the pulse became weak, a slight epileptiform seizure took place, and the heart failed, although respiratory movements continued.	Flabby, rather dilated heart. Valves healthy. Kidneys slightly enlarged and congested. Other organs healthy.
	6	F.	37	Perfectly healthy.	Cautioned not to take food.	?	About ℥ij. used.	? Proposed operation. Operation not begun.	Do.	Took it very well. Perhaps a little more struggling than usual.	Nearly ready for operation when she suddenly turned pale. Upon examination, no heart sounds audible, and no pulse to be felt, but breathing continued for some time. Another account states that after a few respirations the colour changed, and attempts were made to restore respiration, but without success.	Except a little kidney disease, all organs healthy.
	7	F.	35	Extremely nervous.	Dress loose. No food recently.	Sitting.	A little over ℥ij. on Skinner's inhaler.	Several teeth to be removed. ? How many extracted.	During.	Excited during operation, crying and laying hold of operator's hand. Jumped up. Struggled for two minutes. Then fell back. No reapplication of chloroform.	Was dead in less than five minutes after she fell back.	?
	8	F.	Young	?	?	?	?	Three teeth to be removed. Two extracted.	Do.	Signs of returning consciousness, with raising of hands during extraction of third tooth. Only partially anæsthetized throughout.	Expired immediately after lifting of hands, apparently from syncope.	Both lungs in a damaged condition. Heart contracted and empty.
	9	M.	11	Fair; convalescent from measles.	Solid food four hours before.	Lying on couch. Head and shoulders slightly elevated.	Folded napkin.	Six molars to be extracted. Five or six removed.	Do.	Required a good deal of chloroform. Cried out when operation begun. More chloroform given. Breathing normal. Pulse moderate.	Whilst last tooth was being extracted patient cried out and attempted to resist. Just before operation completed colour became bluish-white, the patient became quiet and flaccid, and the breathing weak and shallow.	?

To face page 138

NINETEEN FATALITIES UNDER CHLOROFORM ADMINISTERED FOR THE EXTRACTION OF TEETH—*continued.*

Classes.	*No.*	*Sex.*	*Age.*	*General Condition.*	*Preparation.*	*Posture.*	*Method and Quantity.*	*Nature of Operation.*	*Relation of Dangerous Symptoms to Operation.*	*Phenomena during Administration and Operation.*	*Fatal Phenomena.*	*Post-mortem.*
Class 2—*continued.*	10	F.	16 to 17	Rather anæmic.	?	In dental chair placed at about angle of 45 degrees.	Junker's inhaler.	For several teeth. Seven or eight removed.	Do.	Took it well. After seven or eight teeth out, showed signs of recovery. More chloroform given. Struggled.	After struggling she became opisthotonic, and quickly died.	?
	11	M.	36	Good; able to undergo great fatigue.	'Examined,' and chloroform found to be admissible.	?	?	? Proposed operation. One tooth and three roots removed.	During or after.	Some excitement. Never entirely under influence of chloroform. One tooth and three roots removed. Patient quiet during operation. Was under for five to seven minutes.	After one tooth and three roots removed, respiration and action of heart suddenly ceased. Face blanched. Artificial respiration attempted, but could not be induced.	?
	12	F.	25	?	?	Seated in an easy-chair, some reclining.	℥ij. on an open inhaler.	One tooth to be removed. Operation completed.	After.	Apparently not abnormal.	After operation over and conjunctiva had become sensitive, pupils suddenly dilated, pulse became imperceptible, and face blanched. Although the heart could not be felt beating, breathing continued for about two minutes.	None.
	13	F.	21	Strong, full-blooded. No history of convulsions or fainting attacks.	No food for several hours.	'Was laid on the sofa.'	?	Nine teeth to be removed. Operation completed.	Do.	About ℥j. of chloroform required to produce unconsciousness. After nine teeth had been extracted from upper jaw patient showed signs of coming round.	After signs of returning consciousness appeared, closure of eyes and spasm of hands, arms, and legs, with arrested breathing, were observed. Artificial respiration restored breathing, but when it was suspended another convulsive seizure occurred, and breathing could not again be started.	Evidence of old pleurisy. Kidneys, lungs, and liver congested. No cardiac disease.
	14	M.	8 to 10	A fresh-coloured lad. Has bronchial catarrh in winter.	Clothing loose and chest exposed.	On table. Pillow under head.	Napkin.	Two lower, four upper teeth to be removed. Operation completed.	Do.	Lower teeth first removed. During extraction of upper, patient cried out, struggled, and turned over on his side. Everything apparently satisfactory.	Three to four minutes after operation over, pallor suddenly occurred, and patient died.	None.
Class 3.—Cases in which it is difficult to say whether the dangerous phenomena came on during a deep or a light anæsthesia.	15	F.	17	?	?	?	Skinner's inhaler.	Nine teeth to be removed. Eight extracted.	During.	Took it well. Well under in five minutes. During extraction of eighth tooth showed signs of recovery. A few drops more chloroform given.	During extraction of ninth tooth patient was observed to be cyanosed and pulseless. After artificial respiration for a few minutes she gave a few gasps.	Heart pale and flabby. Fatty infiltration of tissues of heart and body.
	16	F.	21	Fairly nourished. Rather anæmic. Weak heart action.	?	Dorsal.	On lint. A little over ℥vj. used.	? Proposed operation. About thirteen teeth removed.	During or after.	Took it well. Required rather more than usual. After ten teeth had been removed showed signs of coming round. More chloroform given. Breathing good and regular up to this point. No stertor. Three more teeth extracted.	After removal of last three teeth breathing suddenly ceased, pupils dilated, and lips became slightly livid. Pulse was then beating feebly, but it stopped within a minute.	?
	17	M.	33	Active, but not strong.	?	?	Administered 'in the usual way.'	One tooth and one stump to be extracted. Operation completed.	After.	?	Operation had just been completed when patient appeared to faint. A few respirations occurred after this, but the heart's action had failed.	Heart and lungs healthy.
	18	M.	11	?	Prepared by diet, etc., for operation at 11 a.m. Alveolar abscess.	Ordinary easy-chair.	Towel.	Roots of one tooth and then two whole teeth removed. Operation completed.	Do.	After roots removed, struggling occurred. More chloroform given. Operation successfully completed.	When operation over, sudden pallor observed. Breathing continued for about one minute, but no pulse could be felt.	?
	19	F.	?	A barmaid.	None. She was wearing a tightly-fitting new dress.	In dentist's chair.	?	?	?	?	?	None.

Again, note the position in which it is stated that the patient was placed. Failure of circulation is certainly more likely under chloroform if the patient is sitting up than if he is lying down, but by no means all the patients apparently were sitting up, and we need not accept the posture as playing a very great part in the causation of these deaths, though doubtless it was not without some effect.

Now consider the relation which the onset of dangerous symptoms bore to the operation. Here we are met with a very striking and probably most significant fact—only *three died before the operation began.* Two died several minutes after the operation was completed, but in only one of these is the account given really convincing proof that the trouble had not begun before the operation had ceased. Of the remaining fourteen cases all died either in the very middle of the operation, or were at any rate seen to be in a dangerous condition immediately it was completed. Surely there can be no reasonable doubt that these deaths were associated in some way with the shock of the extractions.

Lastly, we find in the records of no less than ten of the cases definite statements indicating that the anæsthesia was partial or very light. Case No. 7 cried out and laid hold of the operator's

hand, struggled for two minutes, and then fell back dead—probably only an extreme example of what happened in most of the other cases. Some of the patients had second or even third and fourth applications of the towel or napkin soaked in chloroform, but not many of them seem to have been properly and evenly anæsthetised throughout the operation.

Let us go back to the physiologists. Several investigators—notably Embley, and Shaeffer and Scharlieb—have shown that in certain circumstances chloroform increases the excitability of the vagus nerve. Now, when the vagus nerve is stimulated the heart is 'inhibited'—*i.e.*, arrested in diastole—and unless the stimulation passes away within a short time, the subject will, of course, die from syncope. It is significant that Embley found that this undue excitability of the vagus was most marked during light chloroform anæsthesia, but disappeared when a deeper level of anæsthesia was attained.

The latest worker in this field is Goodman Levy. He dismisses the idea of sudden death under chloroform being explicable on the grounds of vagal inhibition of the heart. Personally, the author is not quite clear that Levy's arguments in that respect are entirely sound. Much of the work both of Embley and of Schaeffer and

Scharlieb was very convincing, and no modern physiologist other than Levy has yet come forward to say that the heart never is arrested under chloroform as a result of vagal inhibition. But beyond doubt Levy has proved that there is another possible explanation of *sudden* syncope under chloroform, and has indicated the circumstances under which such syncope is likely to arise in a manner which accords in a very striking way with the clinical evidence obtainable from records such as we have just been examining.

Briefly, Levy has shown that under light or incomplete chloroformization the heart may be thrown into a condition of *fibrillation*—an incoherent irregular tremor which takes the place of the regular rhythmic movements of the heart muscle, and which is quite incapable of maintaining the circulation. Levy, then, believes that chloroform syncope is due to incomplete chloroformization, more particularly if the operation be begun during this stage. Even the stimulus of a cut from a sharp knife sends some impulse along the divided twigs of sensory nerves, which is conducted to the sensory part of the brain, and may set up reflex effects elsewhere. The shock of extracting a tooth must give to the brain a far more shattering blow, and surely it needs no great stretch of imagination to suppose

that the blow is reflected along efferent nerves to the heart, producing, if chloroformization is incomplete, the fatal fibrillation described by Levy or the vagal inhibition described by other workers.

Consider now how very much more frequent in dental than in major surgery is *incomplete anæsthesia*, if chloroform given on a towel or napkin be the drug and method; add to the effect of that the further points that the *shock* of extracting a tooth is necessarily very considerable, and that in a large proportion of dental cases it is really essential to secure at any rate some *elevation of the head and shoulders*, if not the full sitting-up posture. Lastly, turn back to the tables of the nineteen deaths and to our analysis of them, and consider in how few of the cases is there any suggestion that the patient may have had an overdose, and in how many there is the clearest possible evidence that the anæsthesia was incomplete and the administration intermittent.

We need not labour the point further. For any minor operation the needs of which can be met by some anæsthetic with a less death-rate than that of chloroform it is most unfair to the patient to choose the drug known to be most lethal merely because it may be a little more

convenient to give. And in no class of case is the choice of chloroform less justified than in dental cases.

As already remarked at the opening of this chapter, there may be met an odd case where chloroform *must* be given for dental extraction. In that case by all means give it, but secure a position as far recumbent as possible, get your patient sufficiently deeply under (and that can and must be done without approaching the stage of overdosage), and keep up a supply of anæsthetic by a Junker bottle, delivering the vapour through a tube passed into the nose, thus preventing the likelihood of the anæsthesia becoming too light during the operation. And ask the operator to be as gentle as he can, and to remember that the patient is far less adequately protected from the results of his manipulations than he would be under nitrous oxide gas or ether.

CHAPTER VII

NITROUS OXIDE AND OXYGEN

The extraordinary success and safety with which nitrous oxide unmixed with oxygen has been given for many years, and given, let us remember, in many cases by persons without much scientific training, need not blind us to the fact that a fairly definite anoxæmia is produced in every real gas anæsthesia, and that lack of oxygen cannot be well borne by many subjects. Older people, particularly with brittle arteries and heart muscles not very strong, do certainly incur a certain risk. Moreover, apart from any risk at the time, anything like prolonged sub-fatal anoxæmia leaves the subject rather dazed and languid for some time. And, lastly, friends or relatives of the patient sometimes wish to remain in the room during an administration (and it is often well that they should do so when the patient is a woman and the dentist a man), and to the lay eye the aspect of a friend or relative under deep nitrous oxide anæsthesia is rather alarming. On every account, therefore, there is

much cause for the strenuous efforts which have been and still are being made to supplant nitrous oxide anæsthesia by that produced by nitrous oxide and oxygen given in combination.

The inquirer into this branch of anæsthesia is met at the very threshold by the difficulty in selecting an apparatus good in itself, and suitable for his requirements, and is apt to lose himself in a mass of makers' catalogues and pamphlets specially written to extol the virtues of one particular machine. Perusal of this literature without a good preliminary grasp of root principles tends to involve the whole subject in confusion, and to make it appear much more complicated than it really is.

There are several points which must be met by an apparatus if it is to be accepted as fit for use. The first and most essential is that it shall provide means whereby the proportion in which the oxygen is added to the nitrous oxide is within the control of the administrator. It will be observed that we do not lay down the dictum that the administrator need be in a position to ascertain *from inspecting his machine exactly what proportion of oxygen he is giving at any particular moment.* It is possible to construct a machine which would fulfil even this very exacting requirement, but only at the expense of very great

complexity. It is enough if he can tell when he is increasing and when he is decreasing the percentage of oxygen, and approximately to what degree. If he knows his job and knows his machine, he will be able to make a fair guess at what proportion of oxygen he is giving, and in the colour of his patient he has a delicate guide as to the accuracy of his technique.

Given this first and most essential point, there are other less vital desiderata in a gas-oxygen machine. According to modern views, it is desirable that some degree of rebreathing can be arranged. The reader is reminded of what was said on p. 52 about the necessity of maintaining a fair proportion of CO_2 in the blood and tissues of the patient. There is every reason to suppose that if nitrous oxide and oxygen be given for a prolonged period purely upon the 'valved principle,' an undue reduction of carbon dioxide may take place, with resulting faintness of respiration, and in extreme cases some damage to the circulation.

Provision may with great advantage be made also for the admixture of ether or ethyl chloride to the gas-oxygen; the former drug is practically essential if the method is to be used for the purposes of major surgery, while the latter is a very great assistance in dental work.

Some machines make provision for warming the gases. This is probably a real advantage, but the author is frankly rather frightened of either an electric or spirit-lamp heater if ether or ethyl chloride is about.

The names of the different gas-oxygen apparatuses are legion, their appearances most diverse, but the underlying principles are few and simple. An article written in 1914 by the present author in the *British Dental Journal*, 1914 (p. 458 *et seq.*), reduced the then recognized methods to four, to which a fifth must now be added. They are as follows:

Hewitt's original method.
Teter's method.
The Guy-Ross method.
Gatch's method (not here to be described, but in some sense the forerunner of the Guy-Ross).
Sight-feed machines.

Hewitt's Method.

About 1886 the late Sir F. W. Hewitt started working at a combined gas and oxygen apparatus, and designed one which would permit of an approximately definite percentage of oxygen to be given.

Hewitt's complete apparatus (see Fig. 24) consisted of two nitrous oxide cylinders and one of

FIG. 24.—HEWITT'S GAS AND OXYGEN APPARATUS.

oxygen, with a combined stand and union and double or concentrically arranged rubber tubes for conducting the gases from the cylinders to the bags. The bags are really formed by putting a septum in one bag, and are connected with a regulating stop-cock, mixing chamber, and face-piece. Nitrous oxide cylinders of 50-gallon size are most convenient, one of these holding about 15 gallons of oxygen.

The foot-key of the N_2O cylinder being turned on, the gas passes to its special section of the bag through brass and rubber tubes of fairly large calibre. The tube for the oxygen is of smaller size, and lies within the other.

The compartments are of equal size, and are only separated by a common indiarubber septum. When filled, they appear almost like a single bag.

The details of the regulating stop-cock and mixing chamber are shown in Fig. 25.

The valves are made of thin sheet-rubber, and the same remarks that were made about those in the ordinary nitrous oxide apparatus apply to them. An inspiratory valve is placed at the mouth of each of the bags, so that the oxygen and the nitrous oxide gas can only pass in one direction—namely, from bag to regulating stop-cock—and not *vice versa*.

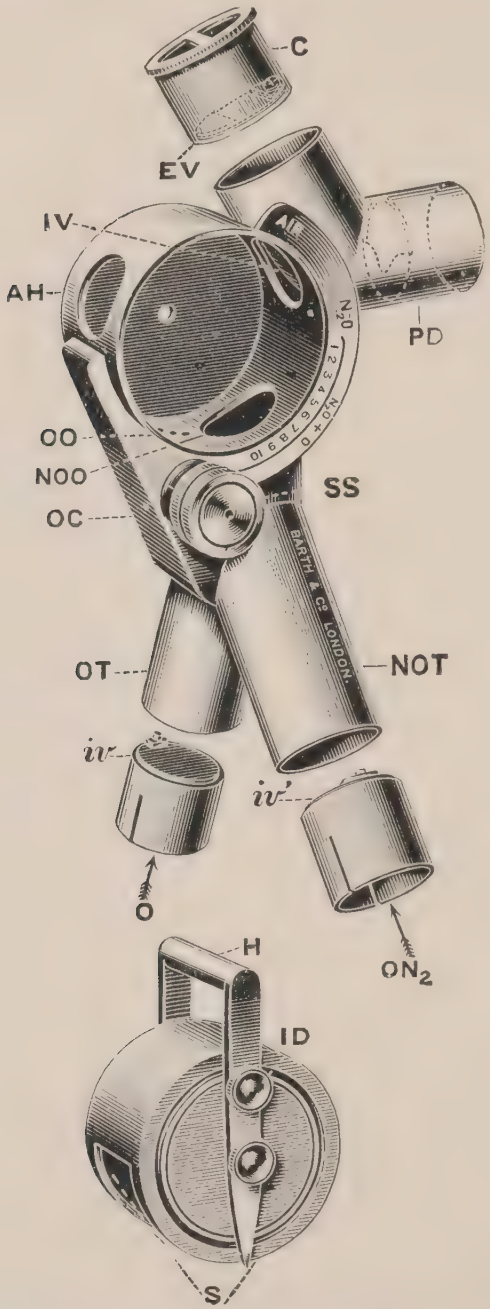


FIG. 25.—HEWITT'S GAS AND OXYGEN STOP-COCK IN PIECES.
(From Hewitt's ' Gas and Oxygen,' Ash.)

NOT, Nitrous oxide tube; NOO, orifice of same; SS, supplementary stop-cock; C, chimney; Figures, per cent. of oxygen; OT, oxygen tube; OO, orifice of oxygen tube; ID, inner drum; AH, air hole; IV, main inspiratory valve; EV, main expiratory valve; H, handle with indicator; S, slot.

The expiratory valve is placed between the stop-cock and the face-piece.

In regard to the relative proportions of nitrous oxide and oxygen which the apparatus is capable of furnishing, much will depend on the degree of distension of the bags during the inhalation, whether they are kept of the same size or not,

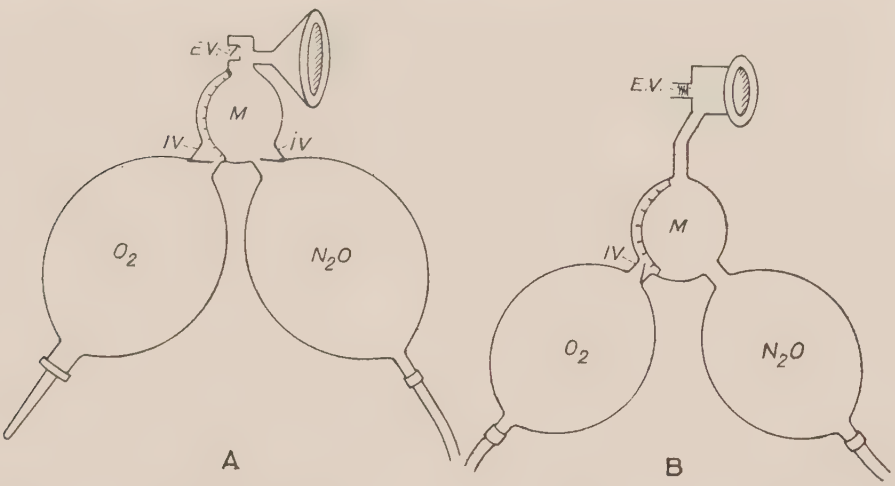


FIG. 26.—DIAGRAMS TO EXPLAIN THE ACTION OF (A) THE HEWITT, AND (B) THE TETER MACHINES.

Note that in the Hewitt both bags are provided with a valve of inspiration as they open into M, the mixing chamber. In the Teter, only the oxygen bag is valved. The expiratory valve (EV) in the Hewitt is a simple flap of rubber. In the Teter, it is a mica disc held up to its seating by a light spring, the force of which can be adjusted.

and at the same time each apparatus possesses slight peculiarities of its own.

Even when due care is taken to maintain an even, moderate tension in both bags, it must not be supposed, nor did Hewitt ever claim, that

the figures ' 2,' ' 4,' ' 6,' etc., on the dial of his machine meant 2 per cent., 4 per cent., etc., of oxygen. All which they actually do indicate is the degree to which the mouth of the oxygen bag is opened up by the movement of the internal drum shown in Fig. 25. But this information is, as a matter of practical politics, quite sufficient for our purpose.

Hewitt's original pattern of gas and oxygen apparatus had two separate bags and tubes; in that form the apparatus is necessarily more bulky and unwieldy, but is less likely to get out of order than the new pattern, in which the occurrence of leakage from bag to bag through the septum is difficult to detect, and may cause confusion and lead to poor results.

The Administration.

The bags should be half-filled with their respective gases, and the face-piece very carefully adjusted. The patient is instructed to breathe freely in and out through the mouth, and when good breathing has been established the indicator should be turned to ' 2.' The indicator is advanced steadily, but not too rapidly, lest excitement rather than anæsthesia be produced. In two or three seconds the indicator may be turned to ' 3,' and then to ' 4,' the bags being meantime

kept as nearly as possible of equal size. It is rarely necessary to have to turn on more oxygen during an ordinary dental case, but more nitrous oxide is always required. If phonation or excitement occurs, the oxygen must on no account be increased, but diminished. Working the indicator on gradually in the course of the first minute, it should have got to about '8,' and, as a rule, a higher percentage than this is not required in dental work.

In female subjects and children this percentage will frequently be used, but for robust people a smaller percentage will be followed by better results.

The Period of Inhalation of Nitrous Oxide and Oxygen.

The time needed to secure a deep degree of anæsthesia varies with different cases.

Sir F. W. Hewitt, however, over a series of very carefully-timed administrations, found the period to be 110·5 seconds on the average, and the corresponding period of available anæsthesia averaged 44 seconds.

We thus find that, while just double the time is required as compared with nitrous oxide, the anæsthesia obtained is only half as long again in duration.

Type of Anæsthesia.

There is under gas-oxygen a much more agreeable type of anæsthesia than under pure nitrous oxide. The colour at which we aim is not the deep blue of gas only, but a dull pink; the respiration is much less noisy and stertorous, and the pupil is very moderate in size. Jactitations are, of course, not seen; their advent would show at once that the oxygen supply had been grossly deficient.

In passing we may remark that the above clinical picture can, if the administration be continued, be maintained quite indefinitely. The amounts of oxygen required increase as time goes on; in long administrations they seem to rise to an extraordinary degree. We may regard 12 to 15 per cent. as a minimum after the first five minutes, and after, say, fifteen minutes one undoubtedly has greatly to exceed this figure. The simplest way to obtain this increased percentage is to open the mouth of the oxygen bag to the full extent, and to increase the pressure in the bag by turning on a free supply from the cylinder.

Recovery of Consciousness.

If the anæsthesia has been of a few minutes' duration only, there is rarely any nausea, and the patient can walk steadily and talk perfectly within a few minutes of lifting the mask. Even after prolonged administrations, the recovery is usually amazingly complete in a few minutes, though a slight and transient nausea is quite common. During one part of his war service the present author spent much of his time administering gas-oxygen from a modified Hewitt instrument to men who required periods of five to fifteen or twenty minutes' anæsthesia while compound fractures were dressed, cleaned, and splinted. Many cases reappeared on the table every two or three days, and some even daily. Yet as one walked round the wards, perhaps half an hour afterwards, one would find practically all these men smoking, or taking nourishment, sometimes quite substantial meals. Beyond doubt, the after-effects of gas-oxygen anæsthesia are amazingly slight.

Comments upon Hewitt's Method.

According to the modern views upon gas-oxygen apparatuses, as set forth on p. 145, Hewitt's machine has several very serious defects.

The most outstanding is that it does not make provision for periods of rebreathing, the im-

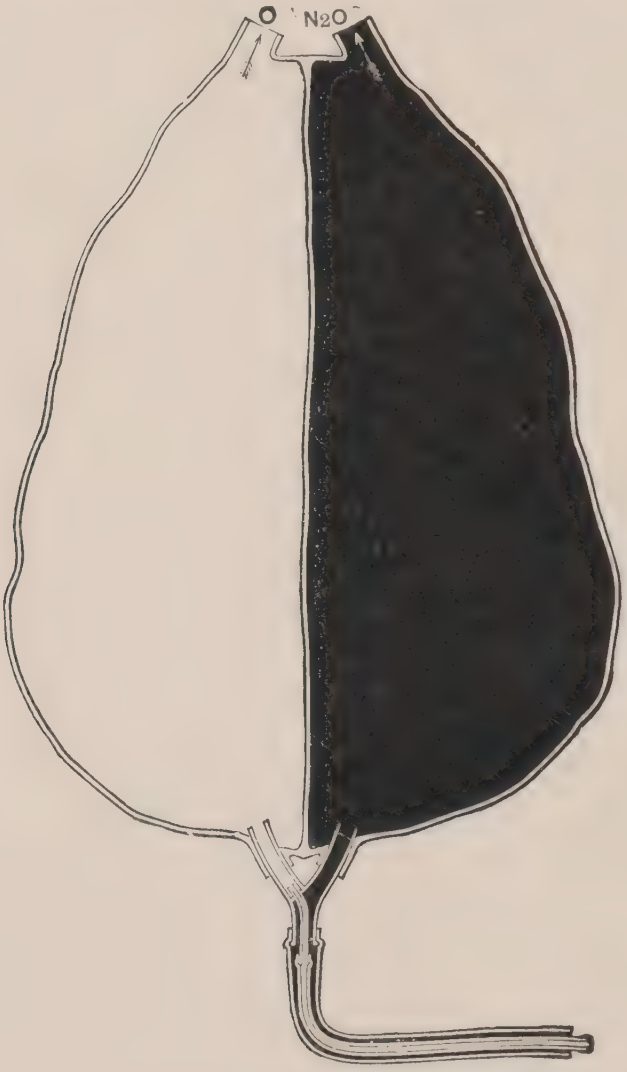


FIG. 27.—CROSS-SECTION OF HEWITT'S N_2O AND OXYGEN BAG.

portance of which this pioneer was not in a position to gauge. Hewitt was, however, beyond everything, an accurate observer and an honest

thinker, and he described with great precision attacks of pallor and faint breathing arising during the administration which we now believe to be due to a reduction of CO_2 in the patient's body.

The apparatus, however, is still described as being historically the first serious attempt to facilitate the administration of gas-oxygen, and to place it upon a scientific basis. Take it all in all, it was a first attempt, highly successful, and is still extensively used by many anæsthetists.

The Teter System (see Fig. 26).

Teter brought out his machine in the first decade of this century. In it he introduced an entirely new principle. He removed the inspiratory valve from the mouth of the nitrous oxide bag, and designed the expiratory valve to open against a slight spring resistance, which resistance can be increased or decreased at will. Observe the results of this alteration of Hewitt's original scheme, and the added powers which it puts into the hands of the administrator. *Firstly,* by maintaining a full flow of gases from the cylinders while at the same time increasing the resistance against which the expiratory valve has to open, it is possible to maintain a certain *positive pressure* of the gases upon the patient. A very little

experience will convince an observer that in this positive pressure he has put at his disposal a potent means of deepening gas-oxygen anæsthesia to a degree not possible without such help. That the method is capable of abuse and can be pushed to a dangerous degree is obvious, but is no argument against its proper use in skilled hands. *Secondly*, by reducing the flow of gases while still maintaining the tension of the expiratory valve, it is possible to cause part of each expiration to return into the nitrous oxide bag (which it will be remembered is unguarded by an inspiratory valve). By delicate manipulation of the two factors—tension of valve of expiration and the flow of gases from the cylinder—it is easy for the expert to arrange for just that degree of rebreathing which is beneficial to the patient, and having reached the correct adjustment, to maintain a good, even anæsthesia without further tap-handling. This was undoubtedly a great advance.

Designing his machine, as he did, on a substantial stand, not intended to be carried about from house to house, Teter had room for several useful additions, notably a chamber in which the gases are heated before being inhaled, and another in which a little ether vapour may be added to the gases in cases where such addition was considered desirable.

Numerous other American machines have been introduced, containing the same principles. Of these we need only mention one. The CLARKE was devised especially for administration of the gases by the nasal method, the maker's pamphlet advocating its use for the production of the state known as *analgesia*. This is a stage reached before the loss of consciousness. In it sensitive dentine can be drilled and even live pulp cavities cleaned out, without the causation of pain to the patient. By using a mixture rich in oxygen delivered at low pressure, the state of analgesia can be prolonged for a considerable time. It is obvious that the least change in the conditions, however, may carry the patient into anæsthesia, a point with which one has to reckon.

All the machines so far mentioned in this group are large and not intended for moving from house to house. An attempt has been made to modify the Hewitt instrument so as to combine its comparative mobility with the advantages of the new principles introduced by Teter. This has been done by removing the inspiratory valve from the mouth of the nitrous oxide bag, and fitting the expiratory valve with a cap, which can be rotated in such a way as to put the valve out of action altogether when desired. This modification, known as BURN'S, which can be carried out easily

upon any existing Hewitt instrument, enables one to secure rebreathing, but would be greatly improved by substituting for the existing expiratory valve one of the Teter type, by the use of which positive pressure could be obtained. The present author used a Burns in France for some months, and was very pleased with it.

The Guy-Ross Method.

This method was developed by Dr. William Guy and the present author in 1912 specially to meet the needs of dental surgeons. Its salient features are as follows:

1. It makes provision for the measurement of the rate of oxygen supply with accuracy quite sufficient for all practical purposes.

2. The mixed gases may be given either on the valved or rebreathing system, and in actual practice the designers used (and still use) rebreathing to a considerable extent.

3. By using the Guy modification of the ordinary Barth three-way tap, as described on p. 98, a dose of ethyl chloride can be added to the mixed gases, thus greatly extending the scope of the method for 'single dose' administrations in dental work. Even a small dose (and the author rarely, if ever, exceeds 3 c.c. for an *adult*)

prolongs the resulting anæsthesia very materially, and renders it adequate for most of the extraction work met with—at any rate, in good class private practice.

The apparatus can be made up in reasonably portable form by using small N_2O cylinders on a

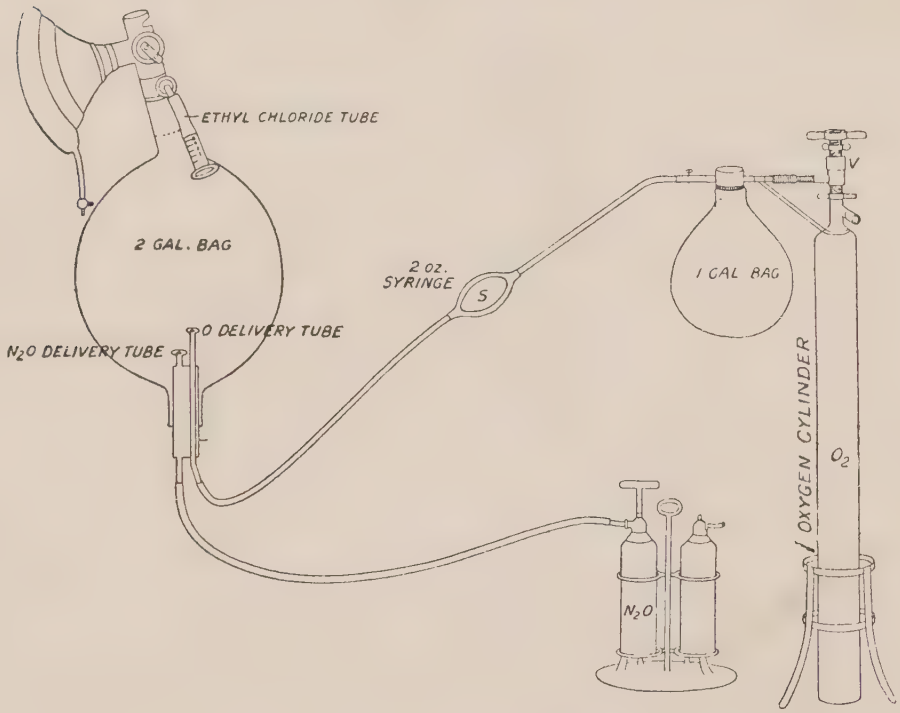


FIG. 28.—DIAGRAM OF THE GUY-ROSS SYSTEM FOR GAS-OXYGEN, WITH ADMIXTURE OF MEASURED DOSES OF ETHYL CHLORIDE WHEN REQUIRED.

The 1-gallon oxygen bag is shown attached by a bracket and rubber tube to a 20-foot oxygen cylinder, but the bag mount may be provided with a union coupling suitable for screwing on to cylinders of the nitrous oxide *type* in which oxygen is usually supplied for dental purposes.

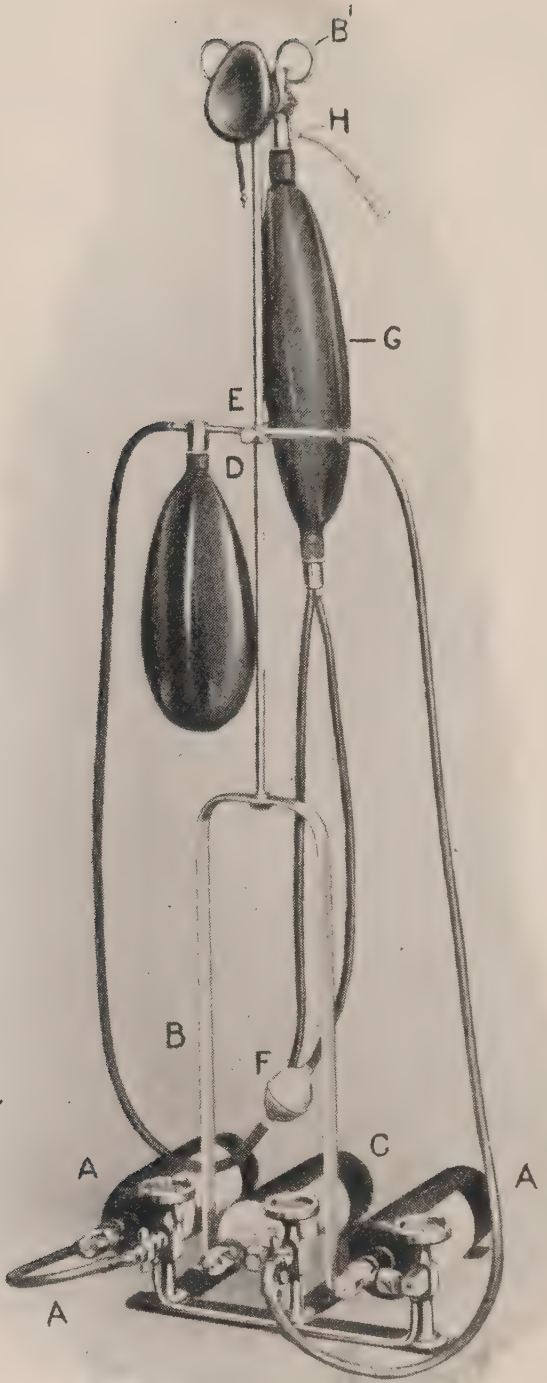


FIG. 29.—THE GUY-ROSS MACHINE FOR GAS-OXYGEN COMBINED WITH ETHYL CHLORIDE.

(For description see opposite.)

foot-frame, and an oxygen cylinder to which the small oxygen bag is affixed may simply be laid on a chair at the side of the anæsthetist. On the other hand, it may be put up on a substantial frame such as is shown in Fig. 29, and stand permanently in the dentist's consulting room.

In the form as figured the apparatus consists of the following parts:

A three-bottle gas-stand with an upright crutch having two 100-gallon cylinders of nitrous oxide and one 30-gallon cylinder of oxygen, all operated by foot-keys. There is a 2-gallon bag with a **Y** tube for admission of the nitrous oxide by one limb from the cylinders, and a 1-gallon bag into which oxygen is admitted by the other limb of the **Y**.

There is the usual three-way stop-cock, which should be provided with an ethyl chloride attach-

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DESCRIPTION OF FIG. 29.

A, two 100-gallon cylinders of nitrous oxide; B, metal upright and crutch, riveted to gas-stand; C, 30-gallon cylinder of oxygen; D, 1-gallon oxygen bag; E, arm supporting the oxygen bag, which by a sliding attachment can be fixed at the most convenient height for the administrator; F, 2-ounce bulb or pump, each compression of which sends forward a charge of oxygen from the oxygen bag D to the gas bag G; G, gas bag; H, bag mount, three-way tap, and ethyl chloride attachment.

ment between bag and face-piece. In the continuity of the tube from the oxygen bag is fixed a rubber pump as used for a Higginson syringe, which, when compressed by the hand, draws at each expansion a known quantity of oxygen from the 1-gallon oxygen bag and drives it into the nitrous oxide bag.

For purposes of description, the administration may be divided into the following three cycles, which can be repeated for an indefinite number of times:

1. Nitrous oxide with as much oxygen as is desired (measured with accuracy and varied according to circumstances) is passed into the 2-gallon bag.

2. The patient rebreathes the mixture for as long as is desirable. As the oxygen factor is consumed by the patient it is kept up by gradual additions from the pump.

3. In a period which varies, but which averages about two minutes, the CO_2 in the bag rises to too high a level. At this point the valves are put in action, and the contents of the bag expired into the outer air.

4. The valves are again thrown out of action, and the bag refilled with an appropriate mixture of the gases.

In the practical conduct of a case we first fill

the gallon oxygen bag. The bulb is squeezed twice to secure any air being expelled before we turn on the oxygen. The three-way tap is put to 'Air,' and the N_2O bag filled. Careful adjustment of the face-piece is now called for, and no leakage of air must be allowed. A few breaths of pure nitrous oxide gas are first allowed on the valves to wash out the air in the upper air passages, and during this period two or three squeezes of the bulb are effected. The tap is then turned full on to 'No valves.' Rebreathing is usually allowed for fifteen seconds, and oxygen then pumped in. Each squeeze of the bulb pumps in 2 ounces of oxygen. It is advisable to increase the percentage of oxygen during the administration, and we find that two compressions give $1\frac{1}{4}$ per cent. of oxygen. If two compressions are given every ten seconds, at the end of sixty seconds the patient will be receiving $7\frac{1}{4}$ per cent. of oxygen.* If two compressions are given every fifteen seconds, the mixture at the end of a minute will be 5 per cent. of oxygen.* It is seldom necessary to give more than two compressions in ten seconds, and seldom wise to give less than two in every fifteen seconds.

No claim is made that the method is mathe-

* Less, of course, quantity consumed by the patient during same period.

matically correct in respect of the oxygen percentage, more particularly as one cannot be certain to what extent it is being reduced by the consumption of the patient and his internal combustion. The figures given are, however, probably reasonably accurate, and the rate of pumping mentioned above is that to which the author, after many years of practical experience, still adheres.

The period of induction seldom exceeds eighty seconds, but it may be longer in special cases. No cyanosis should be allowed to appear, but if by chance it threatens, oxygen should at once be pushed.

The period available is about forty seconds from the removal of the face-piece, if the mixed gases only are employed, but if, as is habitual in the practice of the author, a *small* dose of ethyl chloride be added, eighty to ninety seconds' anæsthesia can easily be attained.

One cannot insist too clearly upon the point that only small doses of ethyl chloride are to be employed, and that by this addition all the anæsthesia usually required can be attained without in any way introducing an element of risk, even though the patient is sitting bolt upright. In an adult of average physique 3 c.c. of ethyl chloride given alone would be entirely

inadequate; given in mixture with nitrous oxide and oxygen, its effect is added to that of the N_2O, and an anæsthesia of some eighty seconds can be relied upon with complete confidence. Moreover, the after-results of these small doses are negligible.

Sight-Feed Machines.

The sight-feed principle could be introduced into any machine, but its great advantage lies in the fact that by it we secure control over the pressure of each gas, and therefore of the richness in oxygen of the mixture, at the very beginning, as it were, and that the remainder of the apparatus may therefore be of the simplest possible type. Indeed, the ordinary three-way tap, face-piece, and 2-gallon bag (Fig. 32), as used for giving gas unmixed with oxygen, may with a sight-feed in circuit serve admirably for gas and oxygen. The sight-feed consists of a glass chamber roofed in by a metal plate perforated by three pipes, two of entry and one of exit. Each gas is led through its appropriate pipe into the chamber, which is filled three-quarters full with water.

An example of a sight-feed is shown in Fig. 30, where the glass sight-feed jar is seen at the head of the apparatus. The actual tubes which carry

FIG. 30.—THE GWATHMEY GAS-OXYGEN SIGHT-FEED MACHINE, WITH THE ECKER NASAL INHALER.

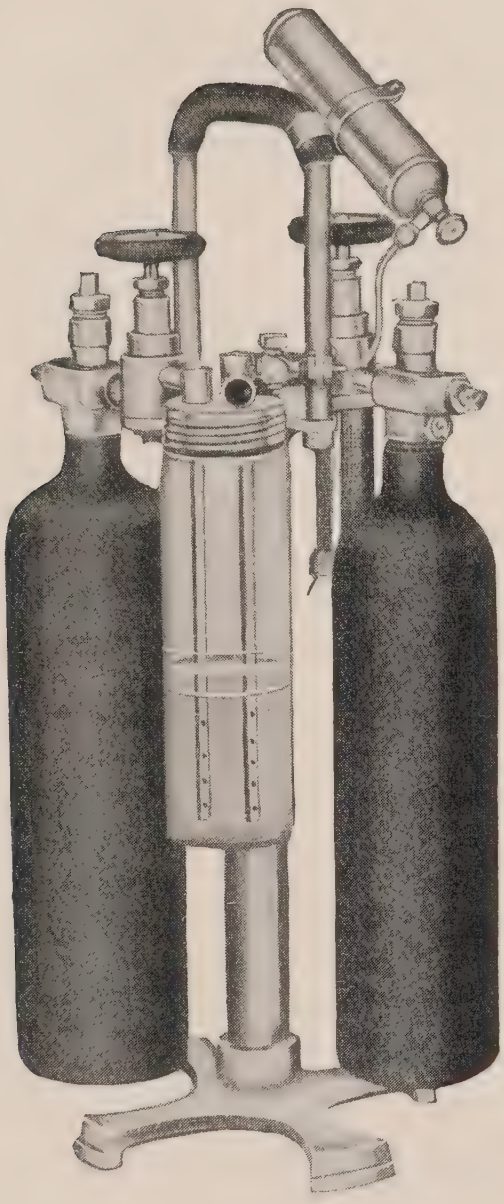

FIG. 31.—GWATHMEY SIGHT-FEED APPARATUS, WITH ERDMAN ETHYL CHLORIDE ATTACHMENT.

each gas towards the jar cannot easily be identified, being incorporated in the upright of the frame, but the student may take it that from the source of supply of each gas such a tube conducts the vapour to pass down one of the metal tubes seen in the figure passing down into the water in the jar. Each of these metal tubes is open at its extremity, and is perforated on its sides by four holes. The water in the jar must come well above the highest of these perforations, otherwise the system by which we estimate the rate of supply does not function. Given a proper depth of water, it will be obvious that if the pressure of gas, whether oxygen or nitrous oxide, be great, bubbles will be seen escaping from the side of supply pipe right down to the bottom of the water, while if the pressure be reduced bubbles will be seen only from the orifices in the upper part of the tube. Upon the surface of the water the two gases meet and mix, and pass from the chamber by the third tube, that of exit, towards the patient. The anæsthetist trains his eye to judge, from the deepest level at which he can observe bubbles from each of the tubes of entry, at what pressure each gas is escaping—that is, to all intents and purposes, how much of each gas is passing from the cylinders into the inhaler from which the patient is

breathing. By manipulation of the taps at the cylinder heads he can secure the mixture which he desires.

An even better idea of the sight-feed system is given by Fig. 31, which illustrates the Gwathmey machine with a special fitment designed by Erdman for adding ethyl chloride vapour. The illustration has been chosen because it shows so clearly one nitrous oxide and one oxygen cylinder, placed one on each side of the sight-feed, and each supplying its contents down one of the metal tubes.

Given this essential and very simple piece of mechanism, the rest of the sight-feed gas oxygen apparatus may be very simple indeed. Most of the designs brought out by makers both in this country and in the U.S.A. make provision for the addition of special attachments which would render the outfit capable of meeting the requirements of major surgery. The chief of these is an ether bottle, which is certainly required if abdominal surgery is in question. All makers are prepared if desired to fit up some means of warming the gases. It is not doubted that the gases act more efficiently and more pleasantly if supplied to the patient at or slightly above room temperature; it is also certain that if some means of heating the metal pipes near their source of

origin is provided, freezing up of the valves is rendered less likely and the flow of gases much more even. Even though an alcohol flame be guarded in a cover of fine mesh wire on the principle of the miner's safety lamp, we cannot, however, be absolutely certain of safety with an ether bottle not far away, while if the heating be effected electrically, there is always the off-chance of a short circuit igniting any ether vapour in the vicinity. One is bound to admit that so far one has not heard of any serious accidents from either of these devices.

The Gwathmey Gas-Oxygen Machine.

This is supplied by the Foregger Company, of New York, in many different forms. In the form shown in Fig. 30, the inhaler attached is intended for nasal administration, but the usual oral mask with valves could be used instead, if the nasal route was not desired. The sight-feed is seen at the top of the frame. The cylinders (of special make and design) are clamped into the frame, and for use their taps are opened in slight excess of the degree probably necessary. The fine adjustment of each gas is regulated by the special control valve built into the frame of the machine; the handle moving the valve is seen

in the middle of each of the two transverses supporting the nitrous oxide and the oxygen cylinders respectively.

The Marshall Gas-Oxygen Machine.

This is made up by Messrs. Coxeter and Son, of London, as is also one of very similar type designed by Mr. Leonard Boyle. Either of these machines may be supplied in forms of varying degrees of portability. The one shown in Fig. 32 is for hospital use, and is therefore fitted with large cylinders and with an ether bottle, shown in the illustration as placed to the right of the sight-feed jar. If desired, one of the devices shown in Fig. 34 and described in Chapter II.* may be placed at the head of each nitrous oxide cylinder, and also, for that matter, upon the oxygen cylinder also. The presence of these regulating boxes does undoubtedly serve, as explained on p. 59, to ensure a much steadier flow of gases than if the supply were taken direct off the cylinder head.

Nasal Gas-Oxygen.

Given a suitable machine with proper provision for regulation of the gases, anæsthetization by the nasal route is a much simpler and easier task

* For description see p. 59; for illustration see p. 34.

than it is if only nitrous oxide gas is available, and anoxæmia has to be avoided by making use

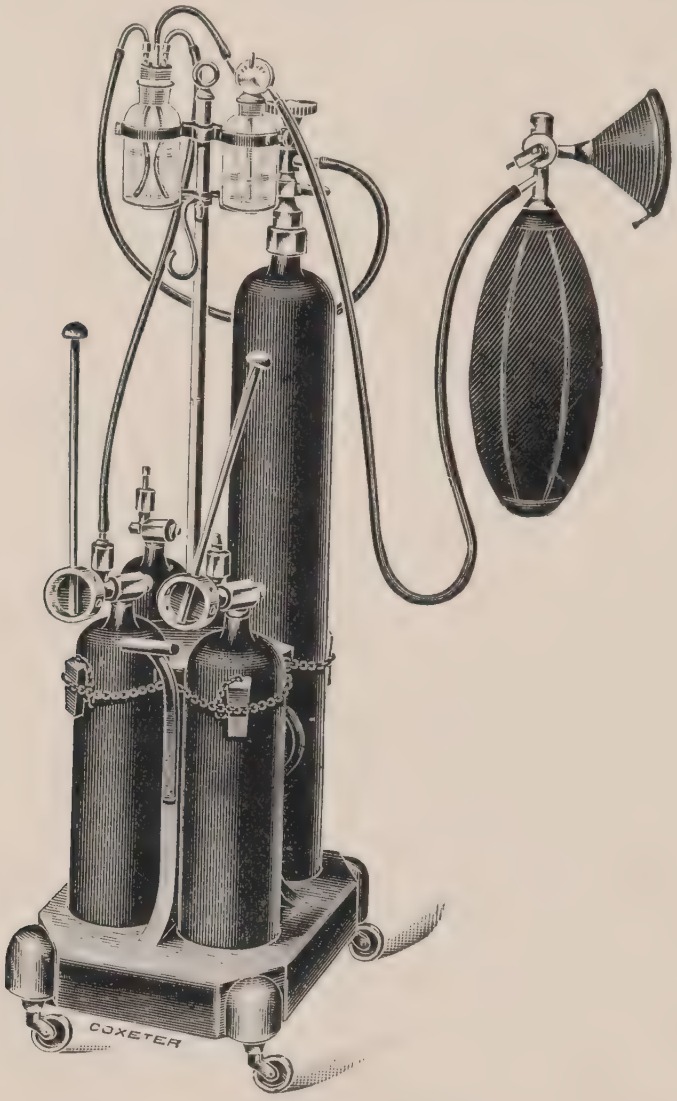

FIG. 32.—MARSHALL SIGHT-FEED GAS-OXYGEN MACHINE.

of atmospheric air. Here again we are faced with a plethora of very good machines by

various makers, and a selection only need be described.

From the section devoted to a description of nasal 'gas' (p. 78 *et seq.*), the reader will remember that in administration by this route the subject is usually directed to breathe at first on the naso-oral system—that is, to inhale by mouth and nose and exhale by the mouth (a valved mouthpiece which will prevent his inhaling *per*

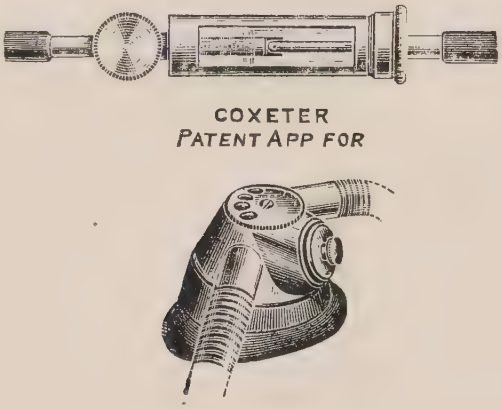

FIG. 33.—DETAILS OF COXETER'S NASAL INHALER AND OXYGEN SIGHT-FEED.

orem being provided for use if necessary)—but that as he falls asleep he usually adopts to-and-fro breathing up and down the nose. The provision of an expiratory valve on the nose-piece is therefore almost essential, but given a nose-piece of good design (calculated to make an air-tight coaptation with any nose of average size and shape) and an expiratory valve, a tube delivering

the mixed gases from any sight-feed machine is all that is requisite. For instance, the Coleman nose-piece (Fig. 17) could be connected up either with a Gwathmey or a Marshall, with excellent results.

To meet the demand of a nasal gas-oxygen

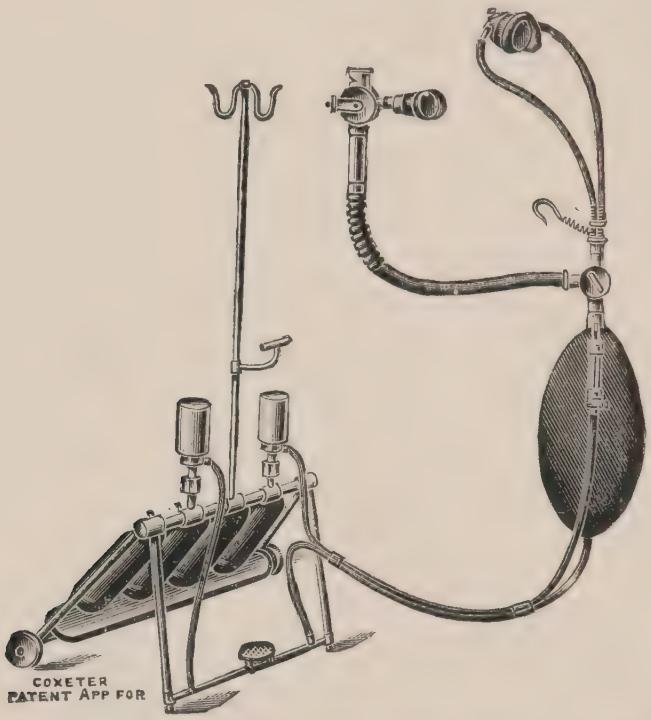

FIG. 34.—COXETER APPARATUS FOR NASAL GAS-OXYGEN.

inhaler which is reasonably portable, Messrs. Coxeter have introduced the apparatus shown in Fig. 34. The cylinders are of the 'angle' type and are obliquely placed, and the supply is controlled by hand-keys not shown in the illustration. Only the oxygen passes through the sight-feed

jar, which is seen suspended by the side of the bag into which the nitrous oxide passes. Both hang together on the dental chair. For nasal administration, the mixed gases are led by two tubes to the nose-piece. By turning a tap placed at the head of the bag just above the point at

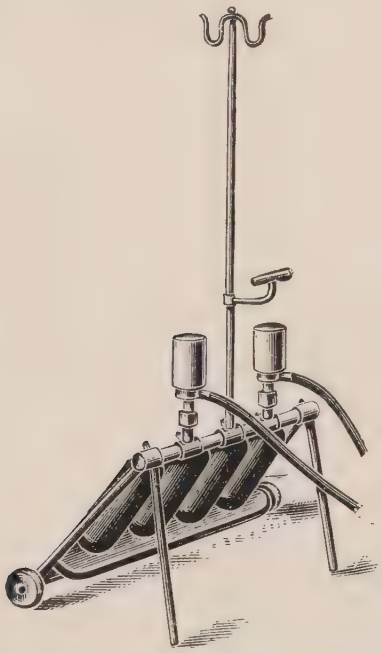

FIG. 35.—ALTERNATIVE FRAME TO THAT SHOWN IN FIG. 34.

which the oxygen is led into the main channel of the machine, the combined gases can be diverted from the nose-piece, to a full face-piece provided as an extra precaution should the patient prove refractory. In some cases it might be wise to induce by the face-piece, and

only fit on the nose-piece after induction is complete. The nose-piece is provided with an

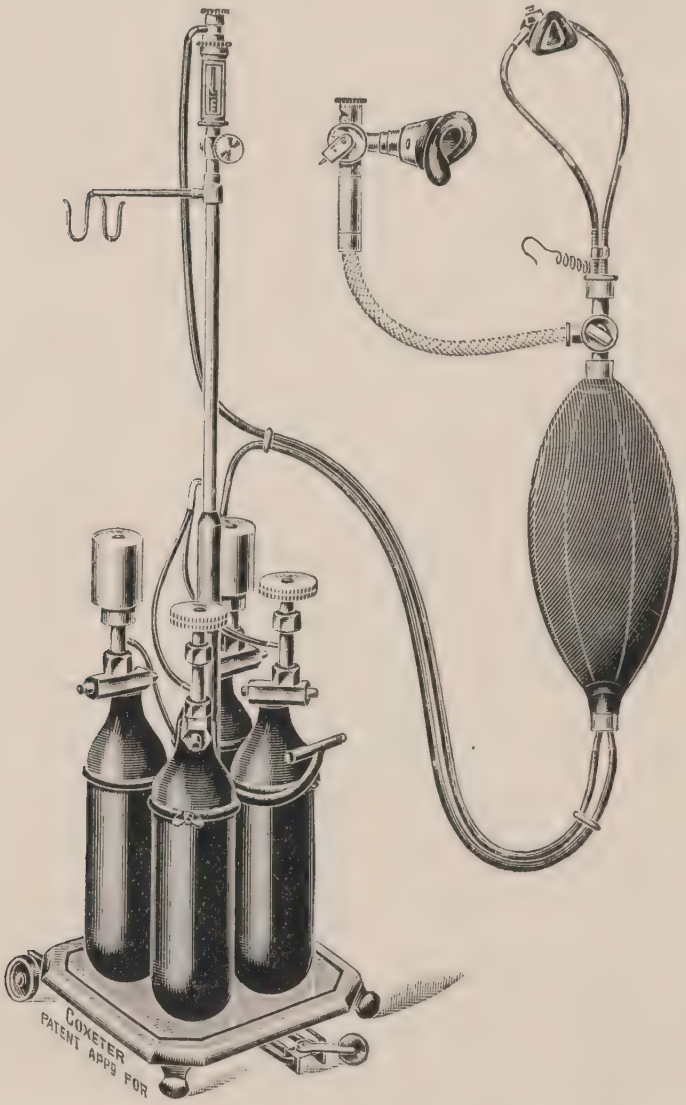

FIG. 36.—NASAL GAS-OXYGEN APPARATUS WITH THE OXYGEN SIGHT-FEED ON THE UPRIGHT OF THE FRAME.

expiratory valve, the amount of lift of which can be controlled at will; there are also holes for

the admission of supplementary air, which can be opened or closed as desired. Two alternative

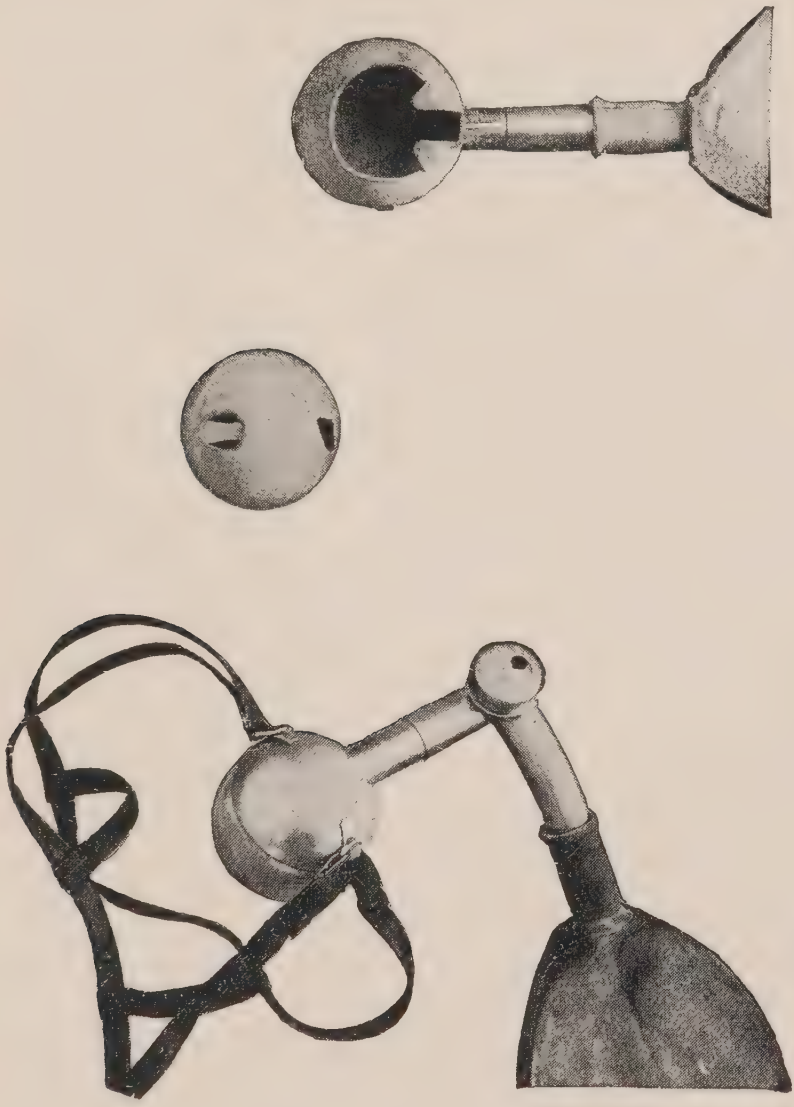

FIG. 37.—ECKER NASAL ATTACHMENT FOR GWATHMEY GAS-OXYGEN APPARATUS.

types of frame are figured; in the one to which the tubing is attached (Fig. 34) there is a foot-valve in the lower horizontal. The propor-

tion of the two gases is first regulated at the cylinder head, and then the rate of supply of the combined gases adjusted by the foot only during the actual administration.

The Ecker nasal inhaler is designed for use with the Gwathmey apparatus, and is supplied by the Foregger Company. It is shown fixed in position on the apparatus in Fig. 30. Dr. Ecker does not find that it is necessary in most cases to supply the gases at a high pressure, and he therefore inserts a small bag in circuit, placed near the nose-piece, and permits rebreathing in and out of the bag. Should the type of respiration indicate the presence of too much CO_2 (see p. 50), the contents of the bag can be squeezed out of the expiratory valve shown at the junction of upright and horizontal portions of the tube. If rebreathing with low pressure supply is to be used, it is obvious that the fit between nose and nose-piece must be a very perfect one, or else air will creep in and upset the result. Dr. Ecker makes his nose-piece of rubber, which can be moulded on to the individual nose. The metal portion of the cap is attached to the dome of the rubber cup, and does not affect the fit (Fig. 37).

Bellamy Gardner's Method for Nasal Gas-Oxygen.

This was the first serious attempt made in this country to adapt the gas-oxygen combination to nasal administration, and has for some years proved eminently successful in the hands of many anæsthetists, particularly, of course, the very experienced ones of Mr. Gardner himself. It is really a modification of the Hewitt instrument, but Mr. Gardner uses the special double bag introduced by A. G. Levy, in which the oxygen bag is placed entirely inside the nitrous oxide one. This arrangement ensures that when the nitrous oxide bag is distended, and the gas therefore escaping to the patient under considerable pressure, an equal pressure is exercised upon the contents of the oxygen bag. The result of this scheme is that the various positions of the indicator of the Hewitt stop-cock (Fig. 25) indicate fairly accurately the proportion of oxygen to nitrous oxide, no matter whether the latter is being supplied at a high or low pressure. In nasal administration, where the pressure used is sometimes much higher than is ever called for in oral administration, security on this point is quite essential to good results.

Gardner further removed the inspiratory valves

from the mouth of both bags, so that rebreathing becomes possible.

Beginning the indicator at '6,' the oxygen element in the mixture is slowly increased up to

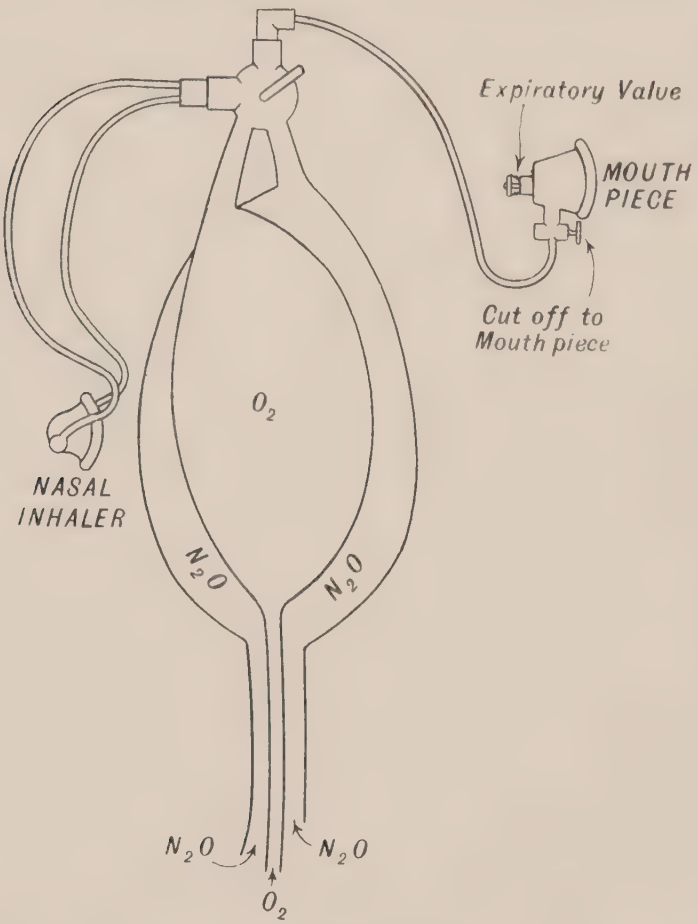

FIG. 38.—DIAGRAM OF BELLAMY GARDNER'S NASAL GAS-OXYGEN METHOD.
(Published by Mr. Gardner's kind permission.)

'15,' and after a period of induction of ninety seconds anæsthesia is usually complete. The outer or N_2O bag should be replenished from

time to time, and kept full, but not allowed to become distended any more than the one which it contains.

The special mouth-cover may be required during the period of induction if the patient inspires too freely through the mouth. One gallon of oxygen usually suffices, so that the replenishing of this bag is usually unnecessary, but the pressure in the nitrous oxide bag must be kept up and in some cases made a little plus. The oxygen, of course, takes the place of the air valve with which we regulate the colour in continuous nasal N_2O anæsthesia, and by carefully regulating the supply according to the patient's requirements a practically normal colour may be maintained throughout, with complete absence of stertor, merely quiet nasal respiration being noticed usually. The pupils become moderately contracted, with a sluggish corneal reflex. The pulse inclines to be quicker and satisfactory in volume and character generally. If the nitrous oxide is pushed and given under any plus pressure some degree of stertor may be noticed, but is easily avoided. The moment to-and-fro nasal breathing is established the N_2O gas should be diminished.

Very good results can be got with this method, and the apparatus has the merit of being fairly easily transported.

CHAPTER VIII

THE USE OF LOCAL ANÆSTHESIA

At the present day a work of this character could not be considered complete without the use of local anæsthetics in dental surgery being considered pretty fully.

In view of the widespread demand on the part of the public for a local anæsthetic in dental practice, and the not unnatural objection which certain persons have to the loss of consciousness, the provision of such means to effect the relief of pain in tooth extraction and other painful dental operations is justified in so far as the means employed are:

(1) Safe;

(2) Efficient; and

(3) Not liable to produce any harmful effects, either immediate or remote.

There is no question that for extensive extractions the exhibition of a general anæsthetic is the safest and most reliable method; but it is also true, in the case of many patients, that the removal of a few stumps or the extraction of

two or three teeth is conveniently and successfully carried out by the use of a local anæsthetic.

The factors considered in the first paragraph of Chapter II. regarding the choice of anæsthetics for dental operations are applicable in this connection also. As a general rule, young children and persons of a neurotic or excitable temperament are unsuitable subjects for local anæsthesia.

The mental attitude of the patient is frequently of very great importance from a constitutional point of view. Many persons have a rooted horror of losing consciousness, and although such cases may be quite good subjects for a general anæsthetic, it is, in suitable cases, advisable to defer to their personal feelings rather than to submit them to the perturbation caused by the *anticipation* of subjecting themselves to the administration of a general anæsthetic.

The best results are got in patients of the stolid, unimaginative type, and in those persons who are easily influenced by suggestion, subjective or otherwise. From experience, it has been observed that this plays a large part in certain cases, and in these it is doubtful if the real anæsthetic and analgesic effects are commensurate.

Apart, however, from such doubtful cases, it is an incontrovertible fact that in thousands of instances complete local anæsthesia *is* induced,

and the means adopted have proved efficient and reliable for the relief of pain.

There have been great controversies in the past relative to the use of local anæsthetics in the practice of dentistry, and there are still many practitioners who have very decided personal views on the subject; but, avoiding excess of enthusiasm on the one hand, and absolute neglect on the other, it is unquestionable that there is a field for this method of treatment, and if it is judiciously, carefully, and scientifically carried out, it has undoubtedly a place in dental practice.

That there are possibilities of dangerous symptoms arising from the use of local anæsthetics must be admitted, but these are mostly due to ignorance, faulty technique, or the administration of too strong doses of the drug, and are usually avoidable.

Fatalities in connection with the administration of local anæsthetics in dental practice have occurred, but are very rare—much more so than in connection with general anæsthetics.

Precautions to be adopted in the administration of local anæsthetics will be dealt with in due course, but on general principles (particularly in the case of the injection of drugs) surgical cleanliness of the part to be injected, absolute sterility of all instruments and drugs employed,

and thorough disinfection of the hands of the operator are a *sine qua non.* In fact, the injection of any drug for the purpose of inducing local anæsthesia and analgesia should never be undertaken except with all the precautions observed in general surgical practice.

The methods employed to produce local anæsthesia and analgesia for purposes of dental treatment are:

1. *The injection of drugs*—(*a*) at the site of the proposed operation (local anæsthesia proper); (*b*) infiltration of the nerve at some part of its course between its origin and distribution (regional or block anæsthesia).

2. *Freezing the gums* by application of certain very volatile substances which evaporate rapidly, and induce local paralysis of the nerve endings of the part by the production of intense cold.

The Production of Local Anæsthesia by the Injection of Drugs.

For a very long time the term 'local anæsthetic' in dental practice was synonymous with 'cocaine,' either under its own or a proprietary name, and it was not until certain disadvantages became apparent from its use that steps were taken to endeavour to find a substitute which had a similar efficiency without its drawbacks.

The principal drugs employed at the present day in dental practice are cocaine, novocaine, and eucaine; tropacocaine, stovaine, and urea quinine have also been employed, but their use is not so general.

Cocainæ Hydrochloridum (Syn. Cocaine).—The hydrochloride of an alkaloid derived from the leaves of *Erythroxylon coca*.

The alkaloid was first obtained by Gaedeke in 1860, and was first used in surgical work by Koller, of Vienna, in 1884.

It is a white crystalline powder (snow), soluble in cold water in the proportion of 2 : 1 and in alcohol 1 : 4; it is also soluble in glycerine.

It is incompatible with soluble salts of silver and mercury, also alkalies and tannin.

Dose—.$\frac{1}{10}$ to $\frac{1}{4}$ grain.

For dental purposes, in order to achieve the best results, solutions should be freshly prepared, and should be boiled beforehand to ensure sterility. Solutions should be isotonic to obviate swelling or shrinkage of the tissues during injection.

A simple formula is as follows:

℞	Cocainæ hydrochloridi ..	grs. iv.
	Sodii chloridi	grs. iv.
	Aq. destillatæ	℥i.

Misce. Sig.: Cocaine injection for dental purposes.

This gives a solution slightly under 1 per cent., and has been found satisfactory for general dental purposes. Its efficiency is said to be increased by the addition of one drop of adrenalin solution (1 : 20,000) to each c.c. (approximately 17 minims) of the injection when used.

The addition of adrenalin is not always necessary, but it is indicated in cases where the gum is spongy, or where the tissues are inflamed or congested. Its vaso-constrictor action localizes the effect of the injection, and at the same time produces a temporary local anæmia of the part, which reduces or entirely prevents subsequent bleeding. It also retards absorption, and by so doing increases the analgesic period induced by the local anæsthetic.

Solutions of cocaine, if kept for any time, are apt to become cloudy, due to the growth of fungi, and to obviate this, chemists usually add a small quantity of boric or salicylic acid to the solution.

There are quite a number of proprietary local anæsthetics on the market under various names of which cocaine is the basis, and these, from the point of view of convenience, are largely used. They vary approximately in strength from 0·75 per cent. to 1 per cent., and are made up with small quantities of preservatives and adjuvants. The same strict precautions should be

adopted in their use as with freshly prepared solutions.

The following is the percentage formula of a stock solution used regularly during a period of four years in over 120,000 cases, which gave excellent results from an anæsthetic standpoint. The cases in which it was used were all under observation, and in no instance was there any report of untoward symptoms, either at the time of the operation or subsequently.

℞	Cocainæ hydrochloridi	0·75 per cent.
	Acidi carbolici ..	0·02 ,,
	Tinct. iodi	0·02 ,,
	Glycerini	10·00 ,,
	Aq.	100·00 ,,

Dose.—Inject for extraction of a single tooth 10 to 15 minims.

The investigations and recommendations of the Committee on Dangerous Drugs have undoubtedly brought out the fact that 'cocaine' is a substance which should be available for use only under the most careful scrutiny, and the means adopted to achieve this purpose are now strictly enforced.

One of the most marked properties of cocaine, apart from its anæsthetic qualities, is the effect it has upon the circulatory and nervous systems,

and the effect produced by a given dose varies greatly with the type of patient on whom it is employed.

The toxic effects of cocaine depend upon—(*a*) the strength of the solution (concentration); (*b*) the quantity injected; (*c*) the idiosyncrasy of the patient.

The strength of the solution is of the greatest importance, and for dental purposes cocaine should never be employed as an injection in solutions of more than 1 per cent.

The quantity injected should be carefully measured, for although it is more dangerous in concentrated form, poisonous symptoms may arise from an unnecessarily large dose of weak solutions.

Certain persons, apparently otherwise healthy, react markedly to small doses of cocaine.

The most frequent minor effect produced subsequent to the use of cocaine as a local anæsthetic is a tendency to fainting or syncope.

The toxic symptoms of cocaine poisoning may not become apparent at the time of the operation, but, owing to delayed absorption, may come on some time afterwards, and it is strongly advised that in all cases where two or more teeth have been extracted by this means the patient should be kept lying down for at least half an hour afterwards.

The symptoms of cocaine poisoning are trembling of the limbs, dryness of the mouth, headache, chilliness, restlessness, and, in serious cases, convulsive movements. Pallor of the face, with a cold, moist skin, is observed; the pulse is feeble and rapid; breathing, at first rapid and deep, becomes feeble and slow; the pupils become dilated (frequently unequal); vomiting may occur; unconsciousness and dyspnœa may supervene.

Treatment consists in using every effort to stimulate and restore the circulation.

Place the patient in the supine position.

Loosen all clothing.

Apply warmth by means of hot-water bottles, or heated bricks wrapped in blanket.

Give alcoholic stimulants (brandy best), hot coffee, or an ether draught.

If unconscious, inject ether (1 drachm), or strychnine ($\frac{1}{50}$ grain).

Keep patient carefully covered, and watch pulse and respirations; if necessary, employ artificial respiration.

Inhalation of amyl nitrite is recommended when blood-pressure is raised.

Chronic cocainism, against which the recommendations of the Parliamentary Committee were chiefly directed, does not fall to be considered here, and it is extremely doubtful if the use of

cocaine in dental surgery ever induced any person to adopt the habit as a direct outcome of having a tooth extracted by means of a local anæsthetic containing cocaine.

Notwithstanding its drawbacks, and when carefully and intelligently used, cocaine still maintains its place as an excellent local anæsthetic for dental purposes, owing to the fact that it gives almost certain results, and that the operation can be carried out within five minutes of the commencement of the injection.

Ethocainæ Hydrochloridum (Syn. Novocaine).—A synthetic compound derived from the amido-benzoic acid series, and represented by the formula—

$$NH_2C_6H_4COOC_2H_4N(C_2H_5)HCL.$$

A white crystalline powder, soluble in water (1 : 1).

It is incompatible with the alkalies, certain salts of silver, potassium, and mercury, and with tannin.

Dose.—$\frac{1}{5}$ to 1 grain.

Solutions are stable, sterilizable by boiling, and it is physiologically compatible with adrenalin preparations.

It is said to be four times less toxic than cocaine (Reclus).

It is similar in action to cocaine, but slower.

It is used for dental purposes in a 2 per cent. solution, usually combined with adrenalin chloride. Twenty minims is an ample dose for the extraction of one tooth.

A convenient tabloid form is also available, and has the advantage that it can be quickly and freshly prepared for each case.

A suitable tabloid formula is:

℞	Novocaini	$\frac{1}{3}$	grain.
	Adrenalini	$\frac{1}{1200}$	,,
	Sodii chloridi	$\frac{1}{8}$	,,

Dissolve one tablet in 20 minims of distilled water by boiling; this gives a 2 per cent. solution.

Novocaine, despite its slower action than cocaine, gives most excellent results, and it has all the requirements of an ideal local anæsthetic. It is free from any irritant properties, and its lower toxicity than cocaine is a strong recommendation for its use.

Benzaminæ Lactas (Syn. Eucaine).—A synthetic compound allied to cocaine.

It is a white crystalline powder, soluble in water (1 : 5).

Dose.—$\frac{1}{8}$ to 1 grain.

A 2 per cent. solution is employed for dental purposes, and it is sterilizable by boiling.

It is said to be less toxic than cocaine, but it is not so efficacious as a local anæsthetic. It is much slower in its action, and has slightly irritant properties.

Its efficiency is improved by the use of adrenalin along with it.

Eucaine forms the basis of several proprietary local anæsthetics which are 'certified free from cocaine.'

Properly sterilized solutions will keep indefinitely.

Dose for injection is 15 to 20 minims of a 2 per cent. solution.

Tropacocainæ Hydrochloridum (Syn. Tropacocaine).—Obtained from 'Java coca.'

It appears in the form of colourless, needle-like crystals which are soluble in water.

Dose.—$\frac{1}{4}$ to 1 grain.

It is antagonistic to adrenalin chloride.

It has been used in 3 to 4 per cent. solutions, 10 to 30 minims being injected.

Its anæsthetic properties are inferior to cocaine, but it is stated to be only half as toxic.

It is slightly irritant to the tissues, and its analgesic effects are more transient.

It is said to produce no cardiac depression.

Amylocainæ Hydrochloridum (Syn. Stovaine).—A synthetic alkaloid from tertiary amylic alcohol.

It is a white crystalline powder, soluble in water (1 : 13).

Dose.—$\frac{1}{4}$ to 1$\frac{1}{2}$ grains.

Has been employed as a local anæsthetic for dental purposes, but more largely used in the production of spinal analgesia.

Quininæ et Ureæ Hydrochloridum.—A white odourless powder, soluble in water (1 : 1).

It has been used as a local anæsthetic for injection purposes in solutions of 0·5 to 1 per cent.

Its anæsthetic power is said to be equal to cocaine, and it has a prolonged analgesic period.

It is sterilized by boiling.

It is stated to be non-toxic, and that it can be freely employed.

Solutions must be freshly prepared, as they decompose readily on standing.

For dental purposes, the drug is put up in sterules with eucaine (each sterule containing $\frac{1}{4}$ grain of urea quinine).

It is compatible with adrenalin.

Technique of Local Anæsthesia by the Injection and Infiltration Method.

1. Preparation of the Patient.—Having decided to employ a local anæsthetic to carry out the operation of tooth extraction, the first care should always be to thoroughly cleanse the mucous membrane in the vicinity of the site of the operation. This is of importance, and, if carefully carried out, greatly minimizes the possibilities of infection, which may cause subsequent trouble from sloughing or necrosis of the part.

The patient should be first instructed to wash out the mouth thoroughly with warm water, with or without the addition of some antiseptic such as phenol sodique, glycothymolene, listerine, or a very weak solution of potassium permanganate.

The gum, palate, and buccal or labial mucous membrane around the site of the operation should then be carefully sponged over with a small tampon of cotton-wool moistened with peroxide of hydrogen, wiped dry with a fresh sterile tampon of cotton-wool, and then swabbed over with weak tincture of iodine (tinctura iodi mitis), care being taken to avoid using the swab too moist. At this stage it is often useful to insert a sterile wool roll or plug of cotton-wool

between the gum and the mucous membrane of the cheek or lip while preparations are being made for injection.

2. INSTRUMENTS.—Injection of the local anæsthetic is carried out by means of specially powerful hypodermic syringes, as in the majority of cases the tissue to be infiltrated is of a very dense nature.

Many types of syringes are employed, but it is

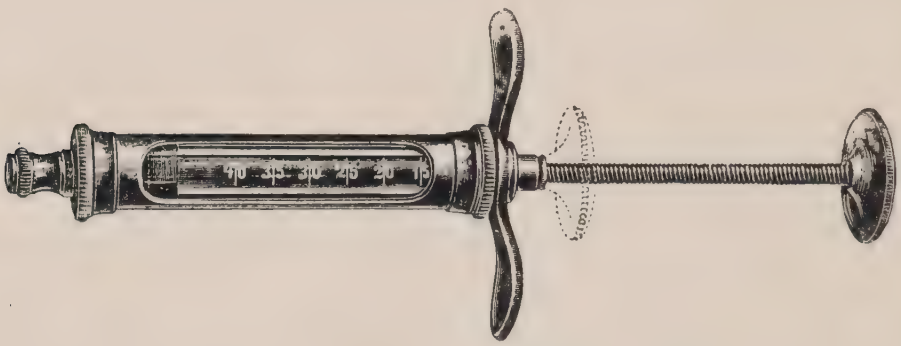

FIG. 39.—SYRINGE WITH EXTENDING PISTON ROD. (Model similar to Pravatz.) Reduced to $\frac{1}{2}$ size.

considered that the best results are got from the use of all metal forms with solid metal plungers, which can be readily taken to pieces for the purpose of sterilization.

Syringes for dental purposes are usually fitted with lateral wings at the point where the piston rod enters the barrel, and the head of the piston rod is sometimes made in the form of a crutch to fit in the palm of the hand. Certain syringes

have an extending piston rod, which can be unscrewed, thus permitting full pressure to be maintained until the barrel is emptied.

A very excellent type of high-pressure syringe, which may be used in the ordinary manner as well, has a screwed piston rod on which is fitted an adjustable screw. This screw fits into a

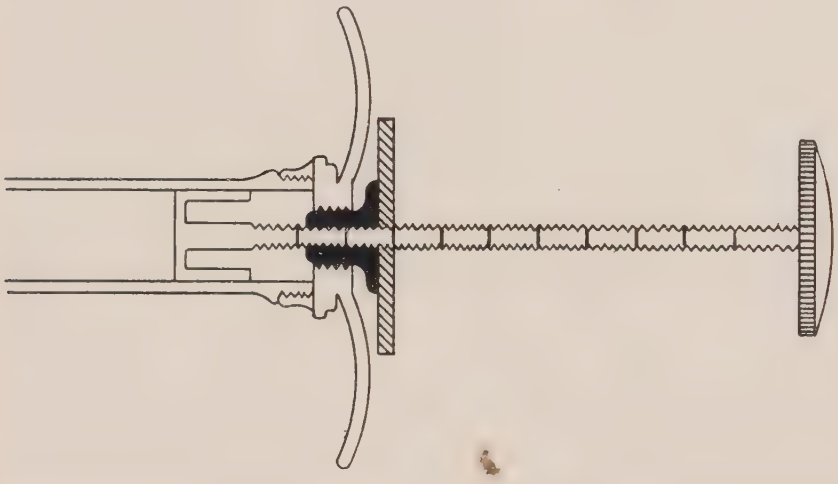

FIG. 40.—SECTION OF HIGH-PRESSURE ALL-METAL SYRINGE WITH ADJUSTABLE FIXING SCREW. (Cathcart.)

counter in the head of the syringe barrel, and locks the piston rod when adjusted. The piston rod is then advanced by a screwing motion, and the contents of the barrel are forced through the needle into the tissues, with little evidence to the patient of the force employed.

The piston rod should be graduated in order that the amount injected may be measured.

The nozzles of dental hypodermic syringes should be screwed on, as the pressure employed is usually too great for the ordinary slip-on form.

The shaft of the nozzle of a dental hypodermic syringe should always be long enough to support the shaft of the needle, leaving only that length free necessary to penetrate the desired depth into the tissues.

Needles.—Special short steel needles are now generally employed for dental work. These have a soft metal head enclosed in a hard metal casing, and when placed in the nozzle and screwed on to the barrel of the syringe, the soft metal acts as a water-tight washer. A fresh needle should be employed for each case. They are easily adjusted and inexpensive, and are put up in sterile glass tubes containing half a dozen, each needle with a fine wire in the lumen. The wire should not be removed till the needle is adjusted to the syringe.

Needles of iridio-platinum were at one time in favour on account of their being easily sterilized by heating to redness in a spirit flame. They were rather too thick and clumsy, and the points were easily blunted and bent.

Sterilization of Syringes.—Sterilization should be effected by regular boiling—*i.e.*, at least once a day when in use. This is most satisfactorily

FIG. 43.—SIDE VIEW OF SKULL

Showing—1. Infra-orbital Foramen; 2. Area of Posterior Dental Foramina.


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FIG. 44.—BASE OF SKULL, SHOWING BONY ROOF OF MOUTH

3. Anterior Palatine Foramen; 4. Point at which needle is entered, to pass in direction of arrowhead towards 4^1 Posterior Palatine Foramen.

FIG. 45.—THE LOWER JAW

Showing—5. Inferior Dental Foramen; 6. Mental Foramen.

accomplished in the solid all-metal syringes where there is no packing on the plunger to become softened and swollen, and which are readily taken to pieces.

After being boiled, the syringe should be kept filled with some antiseptic—5 per cent. carbolic acid is very good—and the nozzle and barrel kept immersed in a beaker containing the same solution. Special beakers, with a hole in the lid, are made for this purpose, and are very useful for keeping the syringe ready for immediate use. If needles are used a second time, they should be carefully boiled in a small capsule over a spirit flame. A few crystals of boracic acid should be added to the solution in which they are boiled. This, however, is not recommended, and a fresh needle should be used for each case.

3. The Injection.—In the majority of instances the insertion of a fresh, sharp needle in the tissues is not attended with any discomfort, the patient only recognizing the actual puncture by a slight pricking sensation, but sometimes this may cause actual pain, and the patient involuntarily starts and prevents the insertion of the needle. This is particularly so when the tissues around the site of the operation are inflamed.

In such cases it is advisable to anæsthetize the surface of the gum first, when the prick of the

needle is made quite painless. This may be done as follows:

(*a*) If the tooth to be extracted is insensitive to cold, as also are any adjacent teeth, a fine spray of ethyl chloride directed on the dried gum at the point where the needle is to be inserted will render it insensitive in a few seconds, and the needle may be safely pushed home as soon as the gum is blanched by the cold (quickest method).

(*b*) A small tightly-rolled tampon of cotton-wool slightly moistened, preferably with isotonic saline solution, is dipped in a few crystals of cocaine hydrochloride on a clean glass slab, and this tampon is then applied to the dried gum at the point of injection, and held there for a little with very slight pressure; in about one minute the surface of the gum is rendered insensitive. A tampon moistened with 10 per cent. cocaine will achieve a similar result when used in the same manner, but takes longer—at least two to three minutes.

In making the puncture, the syringe should be held by the barrel between the thumb, fore, and middle fingers in a manner similar to holding a pen, and a steadying point secured on the jaw by means of the third and little fingers. The fingers holding the syringe should be flexed as

the point of the needle approaches the site of the puncture, and the actual insertion into the tissues made by extending the thumb, fore, and middle fingers. The adoption of this method gives precision, and the tactile sense is immediately informed if the point comes in contact with bone, or if the needle has been misdirected.

When the needle has been pressed satisfactorily home, the barrel of the syringe is kept in position by being held between the adjacent sides of the middle and fore fingers, the thumb is withdrawn, and the ball placed on the head of the plunger, or, in the case of the type of plungers with crutch-shaped heads, until the crutch fits into the fleshy part of the palm at the base of the thumb; when pressure is applied, the middle and fore fingers automatically slip under the lateral wings of the barrel, and the full force necessary for injection is available.

The piston rod should then be pushed home slowly and gently without jerking, so that time is permitted for the dissipation of the fluid in the tissues.

After the first injection is made, it is usually unnecessary to take any measures for the relief of pain in subsequent punctures, as these can generally be made within the margin of the area of the zone of primary anæsthesia.

This leads one to the question of the number of punctures necessary to induce complete local anæsthesia of the part involved in the operation. As a general rule it is found, in the extraction of a single tooth, that three punctures meet all requirements—one in front of and one behind the middle line of the tooth on the buccal or labial aspect, and one on the palatine surface.

Where two or more adjacent teeth fall to be removed by this method, one puncture on the anterior and posterior buccal or labial aspects of the end tooth of the series and a puncture at a point between the adjacent teeth usually suffice for the external surface, one puncture being made on the palatal aspect in the middle line of the tooth in each case also.

The question of the number of punctures is, however, not subject to dogmatism, and must be governed by the requirements of each individual case, the essential being that a complete series of overlapping zones of anæsthesia be developed all round the site of the operation.

Points to be observed in making the Injection.—In order that the best results may follow, it is necessary that the operator should be familiar with the nature and character of the tissue which is to be injected, as well as its anatomical arrangement.

The proper infiltration of the tissues depends on the fluid being directed in such a manner that it is in actual contact with the sensory nerve fibres of the part, and as these with which we are concerned are principally situate in the peridental membrane lining the tooth socket, the injection must be directed so that the fluid is forced into this area.

The peridental membrane is continuous at

FIG. 41,—CORRECT LINE OF PUNCTURE

the neck of the tooth with the muco-periosteum covering the superficial alveolar bone, where it forms the 'gingival cincture,' and from that point it surrounds the root and lines the alveolar socket as a common membrane.

It is essential that the point of the needle, when the discharge of the fluid is taking place, should be as near as possible to the point where the fibrous tissue of the gum and alveolar socket blend, and should be near to the border of the alveolar bone.

The point of the needle should therefore be inserted near to the free margin of the gum, and pushed forward obliquely to the long axis of the tooth towards the root.

In this connection it should be noted that the point of the needle is to be held so that the discharge from the orifice is directed to the side next the tooth.

The puncture should not be deep, and when pressure is applied there should be considerable resistance of the tissues to the injection.

If the needle has been inserted too vertically, it may only pass under the layer of the epithelium, and, when pressure is made, a blister-like swelling appears on the gum, due to the separation of the epithelial layer from the corium. When this occurs, the needle should be partially withdrawn, and pressed home at a more oblique angle, so that the liquid is forced into the deeper fibrous tissue.

When the correct quantity of fluid has been injected—viz., 3 to 5 minims—at the site of the first puncture, the gum should show a small circular pale area, of which the needle-point forms the centre. Each subsequent puncture should produce a similar anæmic area, and these should overlap, so that the whole area of the operation is covered.

If the gum is inflamed, soft, or spongy, there may be some slight bleeding at the site of the punctures, but this does not interfere with the effect of the injection, and is usually transient.

When the fluid passes from the syringe easily, it is usually due either to some slight leakage, which should be corrected, or to the fact that the puncture has been improperly made. If the puncture is made too high up on the root of the tooth, the point of the needle may penetrate into the loose connective tissue where the mucous membrane is reflected on to the surface of the lip, tongue, or cheek; and if too low down near the neck, the point may pass through the flap of gum round the neck of the tooth and the fluid escape. Again, there may be an old-standing sinus, and if the needle-point opens in this, the fluid will escape on to the surface.

If there should be an actual condition of alveolar abscess, the point of the needle may enter the abscess sac, and if fluid is injected, acute pain is caused owing to the increase of tension. It is not recommended in such cases that local anæsthesia be employed, and they are better dealt with by a general anæsthetic; but if local anæsthesia only should be available, the injection must be carefully directed around the abscess sac, and on no account should the fluid be injected

into the pouch of pus. Local anæsthesia by the freezing method is better in these cases if it can be employed.

Apart from the general principles of the method of injection enunciated above, there arise certain minor difficulties which have to be dealt with.

These depend largely upon the position of the various teeth in the mouth, and the local association of the soft tissues.

In the case of the incisors and premolars access is usually easy, but the molars frequently present difficulties owing to the close association of their surrounding mucous membrane with that of the cheek and tongue.

To inject the external alveolar surfaces of the upper jaw and the right side of the lower jaw, the palatal aspect of the upper alveolar margin, and the lingual side of the left side of the mandible, the operator will find it most convenient to stand on the right-hand side of the chair, while the left alveolar margin of the mandible and its right ingual aspect are more readily accessible from the left-hand side.

In the case of the incisors and premolars, retraction of the lips and cheek is performed by the fingers of the left hand; in the region of the molar teeth retraction of the tongue and cheek muscles is best performed by inserting the mouth

mirror into the sulcus, and pressing the tongue inwards or the cheek upwards or downwards and outwards as required. This usually gives a clear view of the site of the proposed puncture, particularly if the patient is warned not to open the mouth too wide.

Most dental surgeons now use straight needle mounts on account of these being less liable to leakage, and in order to ensure direct pressure in a straight line; and if the system outlined above is adopted, it will be found as a general rule that local anæsthesia of any part of the mouth can be effected.

The depth to which the needle will penetrate in the mucous membrane varies, and is governed by the thickness of the membrane covering the alveolar margin at the neck of the tooth. It will be found as a general rule that in the region of the molar teeth the puncture only requires to be comparatively shallow (2 to 3 mm.), while in the anterior part of the mouth it may be considerably deeper. The diagram shows better than a prolonged description the condition of affairs in the molar region.

When the gum around the tooth to be extracted is very much inflamed and spongy, a condition frequently associated with acute or chronic pericementitis, it is much better to

employ a general anæsthetic, as, even when carefully and slowly carried out, the injection method may not give satisfactory results, and frequently causes considerable pain to the patient during the process of injection.

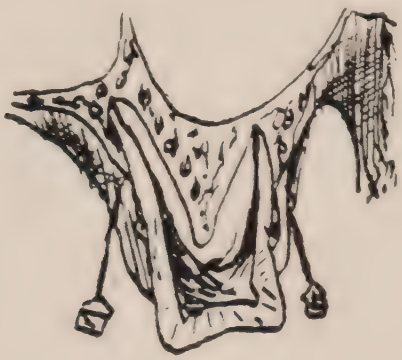

FIG. 42.—SECOND OR THIRD UPPER MOLAR.
(Vertical section.)

After the injection has been completed, it is good practice to instruct the patient to rinse out the mouth well with warm water, and then to gently massage the gum round the site of the operation for a few moments. This helps to diffuse the injection in the part, and incidentally detracts the attention of the patient from the thought of the operation. Before extracting, it is also well to test the insensitiveness of the gum round the tooth by pressure with a blunt probe, and, as the patient feels no pain therefrom, it increases confidence in the effect of the anæsthetic.

It is found in practice (with cocaine preparations) that, after injection of approximately 1 c.c. of a 0·75 or 1 per cent. solution, extraction can be proceeded with in about one minute from completion of the injection. With novocaine, a slightly longer time (four to five minutes) must be allowed to get the best results.

Regional, Block, or Conductive Anæsthesia.

In dental practice this means simply the deep injection of branches of the superior and inferior maxillary nerves, so that the area of their distribution is blocked, and the analgesic effect conducted over the whole region supplied by the particular nerve so treated.

The method* has been known since 1885, when Hall and Halstead (America) first described the production of dental anæsthesia by injecting the inferior dental nerve at the 'spine of Spix,' and the infra-orbital branch of the superior maxillary at the infra-orbital foramen.

It is only of recent years, however, that there has been a revival of the method, and it is undoubtedly the case that complete relief of pain is afforded by it in many painful dental operations.

* *Vide Dental Cosmos*, April, 1885.

A good deal of skill is necessary for the successful accomplishment of the operation of injection, and a thorough knowledge of the anatomy of the parts is essential.

For the general anatomy of the fifth pair of cranial nerves the student is referred to standard textbooks on the subject, and only the practical points relative to the subject in hand can be dealt with here.

The nerve branches supplying the teeth and gums of the upper and lower jaws can be conveniently reached at the following points, where they may be injected:*

A. MAXILLA—(1) *The Infra-Orbital Foramen.*—The infra-orbital branch of the superior maxillary nerve passes through the infra-orbital canal, and emerges at the infra-orbital foramen, which is situated above the canine fossa, below the infra-orbital ridge, and on a line between the centre of the eye and the roots of the first premolar.

(2) *The Posterior Dental* (*Two*) *Foramina* are situated almost in the centre of the zygomatic fossa, and directly above the apices of the roots of the second molar tooth.

(3) *The Anterior Palatine Foramen* directly behind the central incisors in the median line.

* The reader should refer here to Figs. 43, 44, and 45.

(4) *The Posterior Palatine Foramen* is situated in a line with the palatine root of the second upper molar, and at the junction of the hard palate and the alveolar process.

B. MANDIBLE—(1) *The Inferior Dental* (*Mandibular*) *Foramen* is situated a little above the centre of the ramus of the lower jaw, about 1 cm. over the last molar tooth; it has on its inner side a spinous process which may be palpated, and the point of injection lies exactly at the apex of the retromolar triangle or fossa.

(2) *The Mental Foramen* is situated about 4 mm. below and between the apices of the first and second premolars.

Anyone adopting the method of conductive anæsthesia for the first time should familiarize themselves with these points by the inspection of a skull and jaw-bone.

The remarks on anæsthetics in the previous section also apply in this case, and the greatest care and aseptic precautions must be observed in the preparation of the patient and operator, as also with drugs and instruments.

Solutions of cocaine, novocaine, or eucaine may be employed in strengths similar to that used for local anæsthesia, and should always be isotonic; but it is recommended that weaker solutions be employed, as the quantity injected

may be more than double the amount used in local anæsthesia.

An ordinary hypodermic syringe, with a long needle 1 to 1½ inches, may be employed, or the dental syringe may be used with a long needle.

Iridio-platinum needles are recommended on account of their being easily sterilized, the points being sharpened when necessary by holding them against a rotating fine emery disc in the dental engine; but it is found that steel needles answer the purpose equally well, and, if a fresh needle is used for each case, are just as satisfactory.

On account of the depth to which the needle requires to be inserted, it is necessary to exercise the greatest care when performing the injection, in order that it may not be broken.

The injection, or, more correctly speaking, the infiltration of the tissue of and around the nerve, must be done slowly and gradually, and two to three minutes should be spent over the process. Injection should be commenced immediately the needle is inserted, and as it is pushed home to the full extent further small quantities of the anæsthetic should be forced out, the complete charge being diffused into the tissues when the limit of penetration is reached. This ensures that the local anæsthetic thoroughly infiltrates all the tissues in and around the nerve.

Technique and Results.

A. Upper Jaw—(1) *Infra-Orbital Injection* (*Short Needle*).—Stand in front of and to the right side of the patient, take hold of the upper lip at the extreme corner with the thumb and forefinger of the left hand, raise and press the tissues upwards. The point of the needle is inserted at a point above the roots of the first premolar, and directed towards a line with the centre of the eye, keeping the point under the facial muscle, and following the curve of the bone to the infra-orbital foramen, which should be palpated by the second finger; pressure should be maintained by this finger when the point reaches the foramen, so that the injection is forced into the canal. About 20 minims should be injected. This anæsthetizes from the central incisors to the first premolar.

(2) *Zygomatic Injection* (*Long Needle*).—Tell the patient not to open the mouth too wide, pull the lower jaw towards the side to be injected, push the mouth mirror well up inside the cheek, and retract it so that the sulcus directly above the root of the second molar tooth is evident. The needle is pushed home at this point, and directed upwards, backwards, and inwards till with a 1½ inch needle the mount is on a level with

the teeth. About 30 minims should be slowly injected. This anæsthetizes the upper molars and second premolar.

(3) *Anterior Palatine Injection.*—The needle is inserted in papilla of gum immediately behind central incisors in median line.; 10 to 15 minims is sufficient to anæsthetize the gum to the lingual side of the incisors and the anterior part of the hard palate.

(4) *Posterior Palatine Injection.*—The needle is inserted at the junction of the hard palate with the alveolar process in the line of the palatine root of the second molar; 10 to 15 minims is sufficient to anæsthetize the hard palate and lingual alveolar process.

B. Lower Jaw — (1) *Mandibular Injection* (*Long Needle*).—Place the point of the needle at the apex of the retromolar fossa in a line with the crown of the teeth of the lower jaw, the point of the needle being directed backwards, then carry the syringe in an arc to the opposite side of the mouth, pressing it home gently at the same time; this follows the backward and outward curve of the internal surface of the ramus. As soon as the point touches bone, complete the injection. About 30 minims should be injected slowly. This will anæsthetize all the lower teeth on the same side, but the incisors may

not be completely insensitive owing to anastomosis of fibres from the other side of the jaw; injections of both sides of the mandible will give complete anæsthesia of the whole lower jaw.

(2) *Mental Injection.* — Needle inserted just below and between roots of first and second premolars; 10 to 15 minims is sufficient to anæsthetize the lower incisors and canines. This injection need only be employed when the posterior teeth are not involved.

Probably, owing to the greater difficulties met with in mastering this method, and the skill, knowledge, and confidence required to carry it out, it is not nearly so generally adopted as local anæsthesia proper. The results, however, on the whole are very good, and, apart from the operation of extraction, it has a wide field of application in the treatment of painful conditions, such as scaling in acute gingivitis, and in rendering the preparation of deep, sensitive cavities, or even the extraction of pulps, painless.

Many operators give a liquid stimulant to the patient either before or after the operation when local or conductive anæsthesia is employed, and it is found in practice that if the patient is given a small cup of hot coffee or bovril, or a small draught of tinct. ammonii aromat. in water, the tendency to fainting is lessened.

Local Anæsthesia by the Use of Refrigerating Agents.

The local production of intense cold or freezing is well known to induce insensitiveness of the parts of the body exposed thereto, as witness the effects of frost-bite, and this method has been employed for the relief of pain in dental practice for many years.

Certain very volatile substances, which by direct, rapid evaporation lower the temperature, are employed, and are directed in a fine stream or spray on the part proposed to be anæsthetized.

The freezing agents employed for this method are ethyl chloride alone, or a mixture of ethyl chloride and methyl chloride. Ether sprayed on the part through a fine nozzle by means of a bulb syringe used to be also employed, but it is now rarely seen in practice; it is much more unpleasant, and less effective, than ethyl chloride.

Recently a method of inducing local anæsthesia by freezing has been introduced by directing a fine stream of oxygen gas, the temperature of which is gradually lowered by passing it through a chamber containing CO_2 snow, on to the surface of the gum, and this is said to be efficacious. It can also be used to desensitize sensitive dentine in cavity preparation.

The principal means at present in use for the production of local anæsthesia by freezing is undoubtedly ethyl chloride. It is conveniently put up in small glass cylinders with a fine capillary orifice containing 30 to 60 c.c. of the drug. It is similar in chemical composition to the ethyl chloride used in general anæsthesia.

The method of application is as follows: The gum over the site of the operation is carefully dried with a plug of cotton-wool, and a small 6 by 6 aseptic dental napkin folded to include some cotton-wool is placed inside the mouth to protect the tongue and fauces; the cheek or lip is retracted, either by the finger or with the mouth mirror, and the spray of ethyl chloride is directed on to the part. In directing the spray, the cylinder is held in the palm of the right hand, the heat of which is sufficient to produce the requisite pressure inside the cylinder with the nozzle directed downwards. The spray should be first directed on to the napkin or bib round the patient's neck, and then raised till it is impinging on the gums where it is required. The cylinder should be held about 12 to 14 inches from the patient's face, and it is good practice to place a folded napkin over the patient's eyes so that no ethyl chloride may accidentally touch them; this, although painful, is harmless. The

point of the spray should be moved slowly over all the area to be anæsthetized, and when the gum becomes white and frozen, the tube of ethyl chloride should be laid down or handed to the assistant, and the operation proceeded with at once.

The analgesic effects of freezing are very transient, and its application is subject to considerable limitations; indeed, the only satisfactory region where it can be employed is the anterior part of the mouth. If the teeth are sensitive to cold, or if there is an exposed pulp in the vicinity, it may cause acute pain and should not be used.

It is excellent for the removal of fragmentary roots or loose teeth, and it does to a certain extent reduce the pain of an ordinary extraction.

It is noted sometimes, particularly in children, that a slight general analgesic effect is also induced by inhalation of the evaporating drug.

Indications and Contra-indications for Refrigeration and Cocaine Anæsthesia.

Freezing agents are better not used in the following cases also:

1. When the patient cannot breathe, except with difficulty, through the nose.

2. When the patient is a young child or a very nervous, timid person, for with such people the sight of the apparatus, the sensation of great cold, and the smell and taste of the drug in the mouth cause alarm and restiveness, and sufficient time is not allowed to produce proper freezing.

3. If the pulp of a tooth is sensitive to cold, or if the tooth to be removed is close to another with a sensitive pulp. Moreover, if the pulp is sensitive, there is neither advanced caries, abscess, nor fistula, and cocaine will act particularly well in such a case. In hospital practice, of course, teeth with the pulp laid bare are frequently extracted, but such cases are less common among private patients, and should be increasingly so.

4. When the pain produced by the extraction may last a long time, as in a case of acute periodontitis, an extensive extraction, or the removal of a large molar with separate roots. Here the action of a freezing agent would be too brief, and cocaine would be more satisfactory.

5. When the tooth to be removed is a second or third molar, with an operator not thoroughly familiar with the use of coryl, etc., and a nervous patient, who has not sufficient self-control to abstain from movements of deglutition, etc., in consequence of the irritation set up by the drug used for spraying.

Freezing agents are specially contra-indicated for the extraction of the lower molars, especially when the patient has a tendency to the excessive secretion of saliva.

6. When the actual cautery is to be used.

Cocaine is contra-indicated—

1. In patients afflicted with cardiac affections, with aortic disease especially, and those with a weak myocardium.

2. In neurasthenic patients.

3. In anæmic and debilitated people.

4. In those affected with acute or chronic disease of the lungs and organs of respiration.

5. In the obese and women who are suckling.

Refrigerating agents may take the place of cocaine in the following cases:

1. The injection of cocaine is difficult to make when the gums of the patient are soft and fungating. Now, it is especially this condition of the gums which one meets with on the external alveolar border, and this is the most suitable region for the application of freezing agents.

2. When an abscess has formed in connection with a tooth, it is usually due to the presence of advanced caries of the fourth degree, and consequently the pulp does not exist any longer, and any sensibility to cold has completely disappeared; in such a case a refrigerating agent

such as coryl may be used with advantage, more especially as the abscess is formed almost always (except in the lateral incisors of the upper jaw) on the outside of the alveolar border, and causes the mucous membrane to bulge just at the point where it is easiest to produce freezing. The same remarks apply to fistulæ, which are almost invariably due to the pre-existence of an abscess.

3. As regards the position of the tooth to be extracted, difficulties will have to be encountered whatever method of local anæsthesia be employed.

CHAPTER IX

ACCIDENTS UNDER GENERAL ANÆSTHETICS

If anæsthetics are carefully chosen and well given, accidents should in dental work be rare indeed. The student will rightly expect to be informed of what accidents are possible, however unlikely, and of the procedure he should adopt under any given set of circumstances, but the author would remind him that with few exceptions anæsthetic accidents are caused by neglect of some precaution already mentioned. It is the man who 'picks up' his anæsthetics by simply watching others administer, or who gleans his information only from instrument-makers' catalogues, who is liable to have trouble. Beyond doubt seeing others give anæsthetics is vital, but equally vital is it to master the physiological action of each anæsthetic and the principles which underlie the construction of apparatus.

Accidents are usually classified into two groups, and though they overlap to some extent, the

practice has value for descriptive purposes. The two groups are:

(A) Failure of circulation, or syncope.

(B) Failure of respiration.

In order to complete the subject we may add a third group:

(C) Results of high blood-pressure pre-existent in the patient.

A. Syncope.

The appearance of the person who has fainted is so well known that we need not dilate much on symptoms. The face is ghastly pale; the eyes open, with dilated pupils and loss of corneal reflex; respiration is faint and gasping, or, in severe cases, entirely absent; the muscles profoundly relaxed, so that the patient, if sitting, falls into a huddled heap; the pulse is imperceptible.

How can syncope arise in the dentist's room? The most obvious cause is fear, and some people so dread the anæsthetic and the operation that they reach the dental chair in a condition of relative, or even absolute, syncope.

Does syncope ever arise from any other cause? Broadly speaking, if it should occur, it must be from one of three causes: (1) Overdose of the anæsthetic; (2) anoxæmia; or (3) gross disease in the patient.

1. As regards overdose, it is in the case of ether practically impossible to overdose unless the methods described for dental purposes are grossly abused. In Chapter VI. we said all that need be said as to chloroform, which can hardly be called a dental anæsthetic at all. Overdose by nitrous oxide is quite possible, and will be dealt with under anoxæmia. There remains ethyl chloride, and with this drug overdose can easily be, and in the past often was, produced. The reader is referred back to Chapter IV., and particularly to p. 105.

2. Anoxæmia, if unrelieved, will always end in syncope, for no heart can continue to function if supplied with nothing but venous blood, and a heart whose musculature is already damaged by disease will be all the more susceptible to the effects of anoxæmia. In the past, the blue-black colour of profound nitrous oxide anæsthesia has been too lightly regarded. The pitcher goes often to the well, but it gets broken at last. We ought to use gas-oxygen rather than pure nitrous oxide whenever we have the faintest reason to suppose that the patient is otherwise than absolutely sound, and a simple rule is *always* to use it.

3. A full discussion upon the possibilities of syncope from pre-existing disease in the patient

would lead us too far afield. Those interested should consult one of the standard handbooks of surgical anæsthesia. All we need here say is that the commonest conditions from which trouble need be anticipated are heart conditions in which the musculature is degenerated (a well compensated valvular disease, particularly if only mitral, is of little importance) and exophthalmic goitre, or any condition of hyperthyroidism. Myocardial conditions remaining after acute infections, especially influenza, sepsis, and diphtheria, must not be forgotten. They may persist for some time after the acute illness, especially in the case of diphtheria.

Treatment of Syncope.—If a patient is so nervous that he (or she) becomes faint before reaching the chair, probably the best treatment is to allow him to lie down until he recover, and then induce him to patronize another practitioner! Short of this drastic remedy, it is usually possible by the exercise of infinite tact to banish his undue fears and begin the inhalation, when the exhilarating effects of a few whiffs of nitrous oxide and oxygen will soon complete the cure. Exceptionally it may be wise to administer with the patient lying on the sofa instead of sitting in the chair.

Treatment for the other forms of syncope

should, of course, be preventive, but if a mistake has been made, the patient must be lifted out of the chair and laid on the floor, with a small pillow behind the back between the shoulders. The mouth will, no doubt, already be opened by the prop, but it is well to slip in a mouth-gag as less likely to slip out. The finger should sweep out the pharynx to remove all mucus, and the tongue should be drawn out by forceps. Artificial respiration is now the great stand-by, and is best given by Sylvester's method. If an assistant is available, he should compress the abdomen firmly but gently during the movement of expiration, so as to support the diaphragm.

The only drug of real value is strychnine; for an adult a hypodermic dose of $\frac{1}{30}$ grain is correct. The preparation of a dose in an ordinary hypodermic syringe takes up valuable time, and the anæsthetist will be wise to have the drug always available in the form supplied by the firm of Hoffmann-la-Roche, whose 'tubunics' can be made ready in a few seconds. The inhalation of amyl nitrite from a capsule broken into a handkerchief in front of the patient's mouth is sometimes recommended, but is of doubtful utility.

Granting that artificial respiration in the lying-down posture and injection of strychnine are the two stand-bys in syncope, other measures

may have some value as adjuvants. The window should be opened, the body of the patient, however, being protected by rugs so as to maintain body heat. Heat may be applied to the front of the chest by fomentations or a hot-water bag.

The last resort in syncope under anæsthetics is massage of the heart carried out by introducing the hand into the abdomen and compressing the heart through the diaphragm. Unfortunately, this is not likely to be practicable in the circumstances under which dental anæsthetics are usually administered.

B. Failure of Respiration.

Cessation of respiration occurs in all the conditions above described, concomitantly with failure of circulation, but may also happen apart from syncope if the air-way become obstructed. For practical purposes, then, 'failure of respiration,' apart from syncope, is synonymous with 'obstruction of respiration.' While obstruction is in surgical anæsthesia a somewhat fertile source of trouble (or was so in the past, when methods were more crude than they now are), it is not much in evidence during the induction of dental anæsthesia, when the patient is sitting up, the mouth is always propped open, and the

muscles are not so deeply relaxed as to lead to falling-back of the tongue and jaw.

During the progress of the operation, and again later in the recovery stage, there is more likelihood of blocking of the air-way, partial or complete. Blood falling back in the mouth and being insufflated into the air-passages is always a possibility, though reasonable care in sponging and (still more valuable) care not to allow the head to be tilted back reduces this risk to minimal proportions.

Apart from insufflation of blood, but also sometimes associated with it, we may have laryngeal spasm affecting the adductor muscles of the vocal cords. In its early stages this condition is evidenced by a high-pitched crowing noise with each inspiration, but if the spasm be very profound, the noise will cease because no air at all is passing in.

Lastly, there is the possibility of a tooth, a part of a tooth, or the broken blade of a forceps, being insufflated. Usually the foreign body is arrested for a time in the chink of the glottis, setting up a spasm, which completes the obstruction, and perhaps calling for immediate opening of the air-passage below the level of the cords. On the other hand, the body may drop past the cords into one of the bronchi (for anatomical

reasons usually the right), causing as it passes the cords little or no obstruction. A subsequent septic pneumonia is then very highly probable. The prevention of this accident, the nightmare of extraction work, is, of course, the erect posture of the patient, the avoidance of extension of the head, and the most scrupulous care in keeping the finger behind the tooth which is being attacked.

Signs of Commencing Obstruction.—Increase or return of the lividity, which rapidly extends all over the surface of the patient's body; gasping and struggling for breath, terminating in actual convulsions and in cessation of respiration. The violent respiratory efforts, as well as the non-oxygenation of the blood, themselves act as cardiac depressants, and the heart's action is seriously impeded and finally stops.

It must be borne in mind that the actual movements of the chest may continue in spite of the complete occlusion of the larynx, and we must therefore rely only on the *audible respiratory sounds* for evidence that air is entering the lungs.

As regards the general *treatment* of obstructive conditions, the first steps are, as indicated above, to clear the air-way and carry on the breathing. If the blood, mucus, or foreign body be within reach, it should be removed by appropriate measures—finger, throat forceps, or sponge.

Assistance may be given by the old-fashioned smack on the back.

The offending body may be rapidly expelled by the coughing, and complete relief be afforded, or the dyspnœa may pass off suddenly owing to the position of the foreign body becoming altered. On the other hand, if the dyspnœa increases, immediate relief will be called for by tracheotomy or laryngotomy; in young people inversion should first be tried, but with adults this is often practically impossible and waste of time.

The patient should be laid on the floor, shoulders raised and head extended, and the larynx should be opened between the thyroid and cricoid cartilages; a tube, if available, should be inserted—or failing this a clean toothpick—or the wound edges kept carefully retracted by means of a bent hairpin or hook. Artificial respiration should then be started.

If the respiratory difficulty is due to thick tenacious mucus or partially clotted blood and mucus sticking about the pharynx, the patient's head should be bent forward, and he should be encouraged to cough and smacked on the back. If this fails, a coarse, dry sponge on a handle should be thrust well back into the pharynx and withdrawn rapidly with a sweeping movement. If this be done, the operator should be quite clear

that the obstruction is not due to a solid body—loose tooth or the like—or more harm than good may result. Apart from foreign bodies, mucus, and blood, it must be borne in mind that asphyxial symptoms may be produced by spasm of the aryteno-epiglottidean folds (especially in chloroform anæsthesia in young people, infants, and the like), and here the remedy, as originally pointed out by Lord Lister many years ago, is simple rhythmic traction of the tongue.

C. The Results of High Blood-Pressure.

Although this subject has already been mentioned more than once, we may for a moment return to it. Any degree of anoxæmia causes marked constriction of the arterioles and a corresponding rise of blood-pressure. Within reasonable limits, and for a short period, there is no great risk in this rise provided the subject is healthy. But the following possibilities must be borne in mind: (*a*) The heart muscle may be degenerated by fatty infiltration, or by the results of recent infections such as diphtheria, influenza, or sepsis. A diseased heart muscle may be unable to work against an increased peripheral resistance arising from anoxæmia. (*b*) The walls of the arteries may be weakened by

degenerative changes, and therefore certain of them may be unable to stand up against increased pressure. Cerebral hæmorrhage may thus ensue.

For these reasons, the use of nitrous oxide by itself is in certain persons definitely risky, and since we always (and very rightly) tend to err on the safe side, we are gradually displacing it in our work by nitrous oxide and oxygen.

CHAPTER X

THE L.D.S. DIPLOMA AND THE ADMINISTRATION OF ANÆSTHETICS

How far are dentists, holding the L.D.S. diploma only, legally entitled to administer anæsthetics ?

It is often held that this diploma confers the right to administer nitrous oxide, but no other anæsthetic. For this idea, however, there is no actual legal basis, but it has grown out of the fact that nitrous oxide is commonly regarded as one of the dentist's ' tools,' and practically a part and parcel of his calling.

The law is absolutely ambiguous on the point, and in the few cases in which a fatality has occurred, and which have actually come into court to be decided upon, the decision of the presiding judge has largely hinged on the amount of skill presumably possessed by the person responsible for the anæsthetic, and little account has been taken of the fact whether the person administering the anæsthetic actually had any qualification or

not in the way of a diploma. The fact is, of course, that a judge is scarcely capable of dealing with such a technical matter, and he is not in a position to say whether any case was conducted with a proper amount of skill or not.

It is economically impossible, and even if possible, not at all necessary, for every dental anæsthetic to be given by an anæsthetic specialist, or even by a person holding a medical qualification. Nitrous oxide or, preferably, nitrous oxide and oxygen can usually be given with success by a dentist who has received proper tuition. Nasal methods are certainly in a category by themselves, and will probably in this country remain in expert hands, though it is clear from literature that many dentists use them in the U.S.A.

The long and vigorous teaching of anæsthetics by Dr. Wm. Guy has resulted in the men who pass out from the Edinburgh Dental School knowing, and usually knowing very well, the method of nitrous oxide and oxygen combined with minimal doses of ethyl chloride described on p. 160, and doubtless many of them continue to use it freely in private practice, though no doubt many of them prefer to get more expert assistance in special cases. The essential object with which the system was introduced was to

put a method capable of meeting *safely* the great bulk of extraction work into the hands either of the properly trained dentist or of the medical practitioner who devoted some time to reading and study of dental anæsthetics, and took pains to adopt his general knowledge to this special branch.

On one point the present author insists. No one, be he doctor or dentist, can be a safe anæsthetist who has not given serious attention to the subject, and mastered by adequate reading the principles which underlie the various methods and the physiological action of the various drugs. The day has gone by when anæsthetics can be learnt by mere rule-of-thumb.

Again, if a medical practitioner wishes to make a practice of giving anæsthetics for dental work, he must realize that a little extra study is required over and above that devoted to the subject of surgical anæsthesia. The requirements of an abdominal section and a dental extraction are quite different, and so must be the methods used to meet them.

Lastly, in all this we must not forget the patient's family physician. To inform the latter that a general anæsthetic is proposed is but common courtesy, and if there is the slightest suggestion of unsoundness of heart or lungs in

the patient one cannot be too careful to extract from his doctor every possible information which might bear on the question of safety, and to secure from him a definite assurance that he has no objection to the administration.

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